# Anesthesia and Euthanasia

**Web Resources**

Ackerman JL, Bellwood DR (2002) **Comparative efficiency of clove oil and rotenone for sampling tropical reef fish assemblages.** *Journal of Fish Biology.* 60(4):893-901
NAL Call No. QL614 J68
A quantitative examination of the reef fish assemblage at Orpheus Island, Great Barrier Reef, contrasting clove oil and rotenone, sampled 365 individuals of 47 species with clove oil v. 536 individuals of 53 species with rotenone. Number of species and individuals were not found to differ significantly between the two techniques, largely due to variation among samples. *Neopomacentrus bankieri* (Pomacentridae) and *Eviota queenslandica* (Gobiidae) were the most dominant in the samples using either technique. Although the samples appeared to be comparable, only 31 species (45 %) in eight families were common to both techniques. Fishes often recovered before collection when using clove oil and were not driven out of the reef during induction to anaesthesia. Although the samples collected with clove oil approximate the results obtained using rotenone, enclosed rotenone stations are the preferred method for providing relatively complete quantitative samples.

*Descriptors:* sampling, stock assessment, fishery surveys, ichthyocides, toxicants, rotenone, marine ecosystems, coral reefs, *Neopomacentrus bankieri*, Pomacentridae, *Eviota queenslandica*, Gobiidae, Pisces, ISEW, Australia, Queensland, Great Barrier Reef, Orepheus I.


Aguilar NG, Palcios CAM, Ross LG (1999) **Controlled anaesthesia of *Rana catesbeiana* (Shaw) and *Rana pipiens* (Schreber 1792) using xylocaine delivered by spray.**
*Aquaculture Research.* 30(4):309-311
NAL Call No. SH1F8
Frog culture is an expanding industry in many parts of the world, and research on the culture of these animals has increased in recent years. This has inevitably led to a need for convenient handling and sedation, sufficient to enable various procedures to be carried out humanely. The objective of this work was to investigate the effectiveness of controlled anaesthesia using a proprietary xylocaine spray applied to the skin in two commercial species of frog, the Bullfrog, *Rana catesbeiana* Shaw, and the Leopard frog, *Rana pipiens* Schreber 1792.
*Descriptors:* frog culture, anaesthesia, aquaculture development, fish handling, *Rana pipiens*,

*Rana catesbeiana*, Northern leopard frog, bullfrog


Allen JL (1988) **Residues of benzocaine in rainbow trout, largemouth bass, and fish meal.** *Progressive Fish Culturist.* 50(1):59-60
NAL Call No. 157.5 P94
Residues of the anesthetic benzocaine in muscle tissue of rainbow trout (*Salmo gairdneri*) and largemouth bass (*Micropterus salmoides*) were determined after exposure of the fish to 50 mg benzocaine/L for 15 min and withdrawal times of 0-24 h. The mean concentration of benzocaine residues in fish sampled immediately after exposure was 14.0 mu g/g in rainbow trout and 10.6 mu g/g in largemouth bass. Residues were below the control value after 8 h of withdrawal in largemouth bass and near the control value after 4 h of withdrawal in rainbow trout. Although residues of benzocaine were high in fish immediately after exposure, the concentration declined rapidly when the fish were held in flowing fresh water. Fish meal prepared from Pacific salmon (*Oncorhynchus sp.*) that had been anesthetized with benzocaine or tricaine (MS-222) contained residues of 45.1 mu g benzocaine/g or 47.7 mu g tricaine/g.
*Descriptors:* anaesthetics, ethyl aminobenzoate, aquaculture, freshwater aquaculture, self purification, *Salmo gairdneri*, *Micropterus salmoides*, fish culture, residues, benzocaine residues


Allen JL, Vang G, Steege S, Xiong S (1994) **Solubility of benzocaine in freshwater.** *Progressive Fish Culturist.* 56(2):145-146
NAL Call No. 157.5 P94
Benzocaine is an effective general anesthetic for fish. Its solubility was determined in waters of various hardness and pH and over a range of temperatures (from 5 to 30°C). Variations in water hardness and pH did not appreciably affect the solubility of benzocaine, whereas increases in temperature increased solubility from 409 mg/L (at 5°C) to 1,118 mg/L (at 30°C).
*Descriptors:* anesthetics, freshwater fish, solubility, pH effects, temperature effects, water hardness, benzocaine


Amend DF, Goven BA, Elliot DG (1982) **Etomidate: Effective dosages for a new fish anesthetic.** *Transactions of the American Fisheries Society.* 111(3):337-341
NAL Call No. 414.9 Am3
Etomidate (r-(+)-ethyl-1-(1-phenylethyl)-1 H-imidazole-5-carboxylate) is a potent and safe anesthetic for fish. The minimum effective dose for four species of aquarium fish zebra danio *Danio rerio*, black tetra *Gymnocorymbus ternetzi*, angelfish *Pterophyllum scalare*, southern platyfish *Xiphophorus maculatus* ranged from 2.0 to 4.0 mg/liter, and the maximum safe dose ranged from 7.0 to 20.0 mg/liter. In general, the lower the dose, the longer the time for anesthesia, but the faster the recovery time. At 4.0 mg/liter, fish typically entered anesthesia within 90 seconds and recovered within 40 minutes. Etomidate is more effective in alkaline water and

higher water temperature but is not affected by total hardness. Test species varied in their ability to survive extended or repeated exposures to the drug. Etomidate has advantages over other commonly used fish anesthetics and should be evaluated further.
*Descriptors:* anesthetics, ornamental fish, *Danio rerio, Gymnocorymbus ternetzi, Pterophyllum scalare, Xiphophorus maculatus*, etomidate


Anderson WG, McKinley RS, Colavecchia M (1997) **The use of clove oil as an anesthetic for rainbow trout and its effects on swimming performance.** *North American Journal of Fisheries Management.* 17(2):301-307
NAL Call No. SH219.N66
The only anesthetic registered in North America for use in fisheries science is 3-aminobenzoic acid ethyl ester methanesulfate (tricaine or MS-222). Although MS-222 is a very effective anesthesia for several fish species, its application in the field is limited because U.S. Food and Drug Administration guidelines demand a 21-d withdrawal period after exposure to MS-222 before fish can be released and enter the food chain. As a consequence, carbon dioxide ($CO_2$) has been used as a substitute anesthetic; however, induction and recovery times with $CO_2$ are long, and anesthesia is shallow in comparison with MS-222. We compared the efficacy of MS-222 to that of clove oil, a naturally occurring substance, for use as an anesthetic for juvenile and adult rainbow trout *Oncorhynchus mykiss*. Clove oil was as effective as MS-222 in inducing anesthesia in both age-groups. Furthermore, exposure to either clove oil or MS-222 at the concentrations tested was not detrimental to critical swimming speed of juvenile or adult rainbow trout. We propose that clove oil be considered as an alternative to MS-222 for use as a fish anesthetic.
*Descriptors:* swimming, anaesthetics, anesthetics, *Oncorhynchus mykiss, Eugenia aromatica*, clove oil, rainbow trout


Anonymous (1999) **New NZ sedative.** *Fish Farming International.* 26(3):21
NAL Call No. SH151.F5
AQUI-S is an aquatic anaesthetic approved for use in Australia and New Zealand with a ‘nil-withholding’ period - meaning it is safe to use for the transportation and harvesting of food fish. Used in the handling, transportation and harvesting of farmed fish, wild fish and crustacea, its applications include grading, brood stock handling, general husbandry and rested harvesting.
*Descriptors:* fish handling, transportation, harvesting, aquaculture techniques, food fish, anaesthetics, Australia, New Zealand, AQUI-S, Pisces

Barham WT, Caiger KH, Visser JGJ (1979) **The use of benzocaine hydrochloride as fish tranquillizer and anaesthetic in saline waters.** *Journal of the Limnological Society of South Africa.* 5(2):94-96
The anaesthetic effects of various concentrations of benzocaine hydrocloride were tested on *Liza macrolepis* and *Sarotherodon mossambicus* in sea water and diluted sea water, respectively. Induction time for anaesthesia was negatively correlated with increasing anaesthetic concentrations in *L. macrolepis*. In *S. mossambicus*, however, operculum clamping appeared to be responsible for induction times increasing with increased anaesthetic concentration. The tranquillizing effects of low concentrations of benzocaine hydrochloride on *L. macrolepis* was also studied.
*Descriptors:* anaesthetics, saline water, Pisces, *Liza macrolepis*, *Sarotherodon mossambicus*, Mugilidae, Cichlidae


Barham WT, Schoonbee HJ (1990) **A comparison of the effects of alternating current electronarcosis, rectified current electronarcosis and chemical anaesthesia on the blood physiology of the freshwater bream *Oreochromis mossambicus* (Peters). I. The effect on blood pH, $pO_2$, $pCO_2$, glucose, lactate, LDH and HBDH.** *Comparative Biochemistry and Physiology.* 96C(2):333-338
NAL Call No. QP1 C6
A comparison was made of the effects of alternating current electronarcosis, rectified current electronarcosis and the chemical anaesthesia benzocaine hydrochloride on blood physiology of the freshwater bream *Oreochromis mossambicus* over a 7 day period. A statistical evaluation of results, in particular of blood glucose and lactate levels, following narcosis, suggests that the physiological effects of alternating current electronarcosis is the least stressful of the three types of anaesthesia. It is therefore the method of choice for stress studies as well as other studies on this fish species.
*Descriptors:* haematology, fish physiology, collecting devices, anaesthesia, *Oreochromis mossambicus*, comparative studies, electric currents


Barham WT, Schoonbee HJ (1990) **Induction behaviour of the tilapia *Oreochromis mossambicus* Peters (Pisces: Cichlidae) subjected to electronarcosis by various alternating or rectified currents.** *Water S. A.* 16(1):75-78
NAL Call No. TD319 A35W3
Mature tilapia *Oreochromis mossambicus* were subjected to electronarcosis by alternating or rectified currents at various voltages and frequencies and in water of various temperatures and conductivities and their induction behaviour observed. Responses to induction varied from no response through slight response to vigorous response. The results support earlier findings that a 60 V, 50 Hz sine wave is superior to rectified current for electronarcosis of tilapia.
*Descriptors:* fish culture, electric currents, electric stimuli, anaesthesia, narcosis, *Oreochromis*

*mossambicus*


Barham WT, Schoonbee HJ, Visser JGJ (1989) **Some observations on the narcotizing ability of electric currents on the common carp *Cyprinus carpio*.** *Onderstepoort Journal of Veterinary Research.* 56(3):215-218
NAL Call No. 41.8 On1
Some effects of alternating current electronarcosis and of rectified current electronarcosis on *Cyprinus carpio* were investigated. In all instances recovery from narcosis was accompanied by convulsive spasms. Haemorrhaging of the gills was also observed to occur. Carp do not appear to be suitable candidates for electronarcosis.
*Descriptors:* narcosis, fish physiology, anaesthesia, *Cyprinus carpio*, electric currents


Barham WT, Schoonbee HJ, Visser JGJ, Smit GL (1988) **A comparison of red-cell fragilities of electronarcotized and chemically anaesthetized freshwater bream, *Oreochromis mossambicus*.** *Comparative Biochemistry and Physiology.* 91A(2):241-244
NAL Call No. QP1 C6
Red cell fragilities were determined over a period of 7 days for a.c. electronarcotized, d.c. electronarcotized and benzocaine hydrochloride anaesthetized *Oreochromis mossambicus*. Marked differences in osmotic fragilities were apparent between the different treatments. Although a.c. electronarcosis and chemically anaesthetized fish showed only slight shifts in mean cell fragilities (MCF) with time, d.c. electronarcosis produced major shifts in this parameter after 7 days. A.c. electronarcosis and chemically anaesthesia resulted in similar fragility patterns with red cells becoming less fragile over 24 hr and subsequently returning to normal levels. The results indicate that a.c. electronarcosis compares favourably with benzocaine hydrochloride as an anaesthetic in *O. mossambicus*.
*Descriptors:* erythrocytes, hematology, osmosis, anesthetics, electric stimuli, *Oreochromis mossambicus*


Bellwood DR (1981) **Cyanide..an investigation into the long term histological effects of sodium cyanide doses upon the gastro-intestinal tract of *Dascyllus trimaculatus*. Part 2.** *Freshwater and Marine Aquarium.* 4(12):7-9,87-88
NAL Call No. SF456 F7
This part of the article investigates the distribution of cyanide throughout the fish body when cyanide is used as an anaesthetic; how and at what dose the cyanide reaches the intestine; and the influence of food in the stomach upon the movement of ingested cyanide. Cyanide induced anaesthesia is the result of severe and swift oxygen depletion in the cells, although the exact mechanism is not known.
*Descriptors:* digestive system, cyanides, anaesthesia, histopathology, long-term changes,

*Pomacentrus violascens*


Bernardy JA, Coleman KS, Stehly GR, Gingerich WH (1996) **Determination of benzocaine in rainbow trout plasma.** *Journal of AOAC International.* 79(3):623-627
NAL Call No. 381 As7
A liquid chromatographic method is described for analysis of benzocaine (BZ), a proposed fish anesthetic, in rainbow trout plasma. Mean recoveries of BZ from plasma samples fortified at 44-10 100 ng/mL were 96-100%. The method detection limit is 10 ng /mL, and the limit of quantitation is 37 ng/mL. Acetylation of BZ occurs in whole blood after storage at room temperature (i.e., 21°C) for 10 min. However, no acetylation of BZ was detected in plasma samples held at room temperature for 4 h. Mean method precision for plasma samples with incurred BZ residue is similar to that for fortified samples in the same concentration range (relative standard deviations of 0.9 and 1.2%, respectively).
*Descriptors:* haematology, anaesthetics, *Oncorhynchus mykiss*, analytical techniques


Bernier NJ, Randall DJ (1998) **Carbon dioxide anaesthesia in rainbow trout: effects of hypercapnic level and stress on induction and recovery from anaesthetic treatment.** *Journal of Fish Biology* 52(3):621-637
NAL Call No. QL614 J68
The physiological and anaesthetic effects of three different levels of air-saturated and buffered $CO_2$ anaesthesia, $pCO_2$ = 37, 78, or 125 mmHg, were examined in cannulated rainbow trout *Oncorhynchus mykiss*. Complete anaesthesia (no opercular movements) was not achieved by these hypercapnic levels after 20 min of $CO_2$ exposure. Although increasing $pCO_2$ reduced the induction times to the early stages of anaesthesia, it also resulted in increasing hyperventilatory, hypoxaemic, and acid-base disturbances. After a 10-min recovery period, while the respiratory acidosis component of the acid-base disturbance was corrected, there was a significant metabolic acidosis. Recovery time was longest in the high $pCO_2$ treatment where 33% of the fish died. Two additional groups ($pCO_2$ = 37 and 78 mmHg) were exposed to an acute stress prior to the anaesthetic treatment. Stress reduced the hypoventilatory effects of the low $pCO_2$ treatment, increased the recruitment of anaerobic metabolism, and prolonged recovery time. Although the increase in plasma catecholamines elicited by the stress was small relative to the response obtained with the anaesthetic, stress prior to $CO_2$ anaesthesia impaired the efficiency of the treatment. Overall, our results suggest that $pCO_2$ levels above 37 mmHg and/or stress prior to the anaesthesia impair the efficiency of air-saturated and buffered $CO_2$ anaesthesia by exacerbating the hypoxaemic effects of the hypercapnic treatment.
*Descriptors*: fish culture, anaesthesia, respiration, fish physiology, *Oncorhynchus mykiss*, rainbow trout

Billard R (1981) **Effect of Some Fish Anesthetics on Gamete Survival During Artificial Insemination of Rainbow Trout.** *Progressive Fish Culturist* 43(2):72-73
NAL Call No. 157.5 P94
Male and female fish are usually anesthetized during the process of taking spawn. They are placed in a bath with added anesthetic and removed after loss of equilibrium. This paper examines the possible toxicity of anesthetic solutions on sperm and eggs when artificial insemination is performed by the dilution technique. Of the three anesthetics (Phenoxyethanol, Quinaldine, MS-222) tested in the present experiment, only phenoxyethanol showed a toxic effect on fertilization when the concentration in the insemination diluent was higher than 0.05%. This effect was limited to the sperm; the anesthetic did not seem to affect the eggs. Some caution should therefore be exercised when this anesthetic is used to immobilize fish during spawn taking; the risk is very low because the amount of the solution contaminating the gametes is limited and unlikely to reach toxic concentrations ( > 0.05%).
*Descriptors:* induced breeding, spermatozoa, eggs, anesthetics, toxicity, *Salmo gairdneri*


Booke HE, Hollender B, Lutterbie G (1978) **Sodium bicarbonate, an inexpensive fish anesthetic for field use.** *Progressive Fish Culturist.* 40(1):11-13
NAL Call No. 157.5 P94
Sodium bicarbonate was tested as a fish anesthetic at combinations of 142 to 642 mg/l, pH 6. 5 to 7. 5, with rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*), and carp (*Cyprinus carpio*). The combination of pH 6. 5 and 642 mg/l $NaHCO_3$ was the most effective treatment for causing the fish, within 5 min, to cease locomotion and slow opercular rate, but to retain reflex response to pressure on the caudal fin. It is suggested that pH-controlled carbon dioxide release from the sodium bicarbonate caused the anesthetic response.
*Descriptors:* fish culture, anaesthetics, sodium compounds, *Salmo gairdneri*, carbon dioxide, *Salvelinus fontinalis, Cyprinus carpio*

Bouck GR, Johnson DA (1979) **Medication inhibits tolerance to seawater in coho salmon smolts.** *Transactions of the American Fisheries Society.* 108(1):63-66
NAL Call No. 414.9 Am3
Applications of 10 therapeutic and two anesthetic agents to healthy smolts of coho salmon (*Oncorhynchus kisutch*) by conventional methods were followed by two different post-treatment circumstances. In condition 1, fish were treated and then transferred directly to 28% seawater for 10 days; in condition 2 fish were treated and held in fresh water for 4 days before their medium was gradually changed over a 4-hour period to 28% seawater. In condition 1, no mortality occurred among fish treated with 2,4-D, trichlorofon, simazine, quinaldine, or light to moderated doses of MS-222. About 10% mortality occurred among fish treated with formalin and nifurpirinol. High mortality in seawater followed treatments with copper sulphate, hyamine 1622, potassium permanganate, malachite green (one protocol), and heavy doses of MS-222. In condition 2, mortality was reduced but still high for copper sulphate and potassium permanganate, much lower for malachite green and hyamine 1622, and zero for the other agents. The results

indicate that additional recovery time in fresh water is necessary between some treatments and exposure to salt water.
*Descriptors:* salinity tolerance, drugs, smolts, mortality causes, *Oncorhynchus kisutch*, juveniles, anaesthetics


Boulle D (1998) **The new threat looming for Indian Ocean coral reef fisheries.** *Window Newsletter. Mombasa.* 9(2):1-2
ISSN: 1024-4158
Live fish capture which has been an old Chinese custom for centuries which was only practised on culture or freshwater species, involved keeping fish alive until eaten. The marine live fishery was born at the same time as the advent of cyanide fishing. This practise which is highly developed in the Western Pacific region is now making its appearance in the Indian Ocean, with operations already reported in the Maldives and Seychelles. Although cyanide fishing has two major advantages: firstly it is fast acting anaesthetic and secondly, fish exposed to cyanide quickly recover with no apparent side effects, if transferred to clean water and no residues detected in fish tissues after few days, this has lead ultimately to huge decline in coral reefs with an associated collapse of reef fishes and crustacean stocks. The logistics of transporting the fish across large distances, high demand and profit margins encourage fishing effort even after the targeted species are too rare to sustain a viable production. In an effort to safeguard the Western Indian Ocean reef fishery, managers and researchers need to be vigilant of the new developments, prepare strategies, plans and new policies that will address the problem.
*Descriptors:* coral reefs, reef fisheries, anaesthetics, resource conservation, fishery policy, catching methods, cyanides, stupefying methods, ISW, Indian Ocean, Southwest


Braley H, Anderson TA. (1993) **Changes in blood metabolite concentrations in response to repeated capture, anaesthesia and blood sampling in the golden perch, *Macquaria ambigua.*** *Comparative Biochemistry and Physiology, A.* 103A(3):445-450
NAL Call No. QP1 C6
The major metabolic changes associated with repeated capture, aquarium transfer, anaesthesia and blood sampling were investigated in an Australian freshwater fish, the golden perch (*Macquaria ambigua*). A compounded stress response was seen after repetition of the procedure, in which the plasma glucose rose within 3 hr and amino acid concentrations rose and the serum free fatty acids concentration fell after 24 hr. Alanine was identified as an important circulating energy store in the stress response of golden perch. No change was noted in the serum protein, plasma lactate or beta -hydroxybutyrate concentrations, indicating that tissue damage and hypoxia were absent, and that degradation of free fatty acids did not produce metabolites excess to the requirements of gluconeogenesis and the tricarboxylic acid cycle.

*Descriptors:* freshwater fish, fish physiology, metabolism, blood, fatty acids, anaesthesia, biological stress, *Macquaria ambigua*, glucose, amino acids, lactate, beta -hydroxybutyrate, levels, sampling, capture


Brattelid T, Smith AJ (2000) **Methods of positioning fish for surgery or other procedures out of water**. *Laboratory Animals*. 34 (4):430-433
NAL Call No. QL55 A1L3
*Descriptor:* fish, surgery, techniques, animal welfare

Brown LA (1987) **Recirculation anaesthesia for laboratory fish.** *Laboratory Animals.* 21 (3):210-215
NAL Call No. QL55 A1L3
An economic reliable long-term recirculation anaesthesia system for laboratory fish is described. Anaesthesia of channel catfish (*Ictalurus punctatus*) was induced within 60 s and was maintained for up to 40 min using tricaine methanesulphonate; recovery occurred within 30-60 s. Various surgical procedures were performed on the fish. No deaths were recorded. All water-quality parameters tested over 19 days use of the system remained stable except for total ammonia nitrogen and, by calculation, un-ionized ammonia which increased to a maximum of 0 multiplied by 23 mg/l.
*Descriptors:* anesthesia, aquaria, recirculating systems, fish culture, *Ictalurus punctatus*


Bruecker P, Graham M (1993) **The effects of the anesthetic ketamine hydrochloride on oxygen consumption rates and behaviour in the fish *Heros (Cichlasoma) citrinellum* (Guenther, 1864).** *Comparative Biochemistry and Physiology, C.* 104C(1): 57-59
NAL Call No. QP901 C6
Heros citrinellum (0.106 to 0.357 kg) were injected with 30 mg/kg ketamine hydrochloride via the dorsal aorta or caudal vein. Immediate loss of balance and complete cessation of fin movement was observed post injection for one to 41 min. Ventilation was barely perceptible or ceased altogether within one minute after injection. Balance returned within 57 to 263 min after injection. Oxygen consumption rate was significantly higher during anesthesia than during control experiments, and significantly lower than during sham treatments. The safety margin of the drug was reduced at tropical temperatures versus temperate conditions. The usefulness of this drug in reducing the stress of prolonged handling, such as during transport, was not indicated. However, injectable ketamine would be useful in reducing the effects of handling larger freshwater tropical fish over shorter time periods.
*Descriptors:* fish physiology, anaesthesia, pharmacology, hazard assessment, temperature effects, *Heros citrinellum*, anaesthetics, ketamine hydrochloride, oxygen consumption,

behaviour, Pisces


Carrasco Meza S (1983) **Immobilization of carp(*Cyprinus carpio*), catfish (*Ictalurus punctatus*) and tilapia (*Tilapia mossambica*) using xylocaine with sodium bicarbonate.** *Thesis, Universidad Nacional Autonoma de Mexico (Mexico). Fac. de Med. Vet. Zootec.* 33 pp.
Anesthetic solutions (xilocaine and xilocaine with sodium bicarbonate) were tested on carp (*Cyprinus carpio*), catfish (*Ictalurus punctatus*) and tilapia (*Tilapia mossambica*). The fish were immersed in the 2 solutions so that the anesthetic would penetrate the gills by diffusion. The catfish was the most susceptible (250 mg/l.) followed by the carp (350 mg/l.) and the tilapia (2000 mg/1.). The carp and catfish had a similar induction period. Tilapia showed the smallest induction period but needed the highest xilocaine concentration. Xilocaine with sodium bicarbonate reduced the induction period in carps and in some cases in catfish and tilapia. In tilapia the xilocaine concentration was reduced to 250 mg/l. and 350 mg/l. An increment in the recovery period was observed in the 3 species. The use of xilocaine with sodium bicarbonate gave more practical results.
*Descriptors:* anesthetics, *Cyprinus carpio, Ictalurus punctatus, Tilapia mossambica*, freshwater fish, Mexico, xylocaine


Carrasco S, Sumano H, Navarro-Fierro R (1984) **The use of lidocaine-sodium bicarbonate as anaesthetic in fish.** *Aquaculture* 41(4):395-398
NAL Call No. SH1A6
Lidocaine and lidocaine-sodium bicarbonate mixture were evaluated as anaesthetics for carp (*Cyprinus carpio*), catfish (*Ictalurus punctatus*) and tilapia (*Tilapia mossambica* = *Oreochromis mossambicus*). Although both induced anaesthesia, the mixture was more effective for induction and recovery, and was able to achieve the required time for the fish to be out of water.
*Descriptors:* anesthetics, lidocaine, animal breeding, aquaculture, *Cyprinus carpio, Ictalurus punctatus, Oreochromis mossambicus*, lidocaine, lidocaine-sodium bicarbonate


Cataldi E, Di Marco P, Mandich A, Cataudella S (1998) **Serum parameters of Adriatic sturgeon *Acipenser naccarii* (Pisces: Acipenseriformes): effects of temperature and stress.** *Comparative Biochemistry and Physiology, A.* 121A(4):351-354
NAL Call No. QP1 C6
Data on the concentrations of some blood constituents of captive Adriatic sturgeon, *Acipenser naccarii*, a primitive bony fish, are reported. Serum osmolality, $Na^+$, $K^+$, $Cl^-$, $Ca^{++}$, cortisol, glucose and total protein concentrations were measured. The effects of anaesthesia, temperature, crowding and prolonged handling stress were tested on a group of 12 4-year-old sturgeons

sampled repeatedly. The anaesthetic does of MS 222 (140 mg/l) induced significant osmolality elevation in the sturgeon. After exposure to colder temperature (17°C versus 25°C), cortisol and $Cl^-$ concentrations significantly decreased. The cultured sturgeon did not seem susceptible to crowding and prolonged handling stress, since neither the serum cortisol and glucose levels nor the other blood parameters were affected by these stressors. Results are compared with the few available data on other chondrostean fish and with those on teleosts.
*Descriptors:* captivity, biological stress, haematology, serological studies, temperature effects, fish culture, anaesthesia, *Acipenser naccarii, Adriatic sturgeon*


Chapman DC, Jackson UT, Hubert WA (1988) **Method for separating normal striped bass larvae from those with uninflated gas bladders.** *Progressive Fish Culturist.* 50 (3):166-169
NAL Call No. 157.5 P94
The anesthetic tricaine was used to separate normally developing larvae of striped bass (*Morone saxatilis*) from larvae with uninflated gas bladders. The procedure was most successful between 23 and 40 d posthatch, and was used to provide thousands of striped bass larvae in which the frequency of gas bladder inflation exceeded 99%. Few normally developing fish were lost due to handling mortality or inadvertent disposal with fish having uninflated gas bladders. The procedure has applications in research, production-scale fish culture, and fishery management.
*Descriptors:* grading, swim bladder, anaesthetics, abnormalities, *Morone saxatilis*, fish culture, normal vs. uninflated, tricaine


Chatain B, Corrao D (1992) **A sorting method for eliminating fish larvae without functional swimbladders.** *Aquaculture.* 107(1):81-88
NAL Call No. SH1 A6
The authors describe a simple sorting method for separating cultured fish larvae with functional swimbladders from those without based on density differences. The whole population was first anaesthetized with MS 222 and then the fish were separated: fish with a functional swimbladder float and those without sink. The efficiency of the separation method was tested at several anaesthetic doses (0.02 to 0.1 g/l) with sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus auratus*) larvae in the 6-34 mm (total length) range. The minimal sorting size was 15 mm for sea bass with an optimal anaesthetic dose of 0.07 g MS 222/l. There were not enough data to draw conclusions for sea bream. The method was satisfactory when applied in real conditions to a large (90,000) population of sea bass fry with an efficiency ratio of over 80%.
*Descriptors:* fish larvae, aquaculture techniques, fish culture, *Dicentrarchus labrax, Sparus aurata*, swim bladder, separation processes


Chiba A, Chichibu S (1992) **High-energy phosphate metabolism in the phenthiazamine hydrobromide anesthetized loach *Cobitis biwae*.** *Comparative Biochemistry and*

*Physiology, C.* 102C(3):433-437
NAL Call No. QP1 C6
Changes in the metabolism of high-energy phosphates after administration of an anesthetic, phenthiazamine hydrobromide (2-amino-4-phenylthiazole; APT), were studied in the loach (*Cobitis biwae*) by in vivo $^{31}P$ nuclear magnetic resonance ($^{31}P$ -NMR). Anesthetic effects appeared at about 7 min after the loach was placed in 50 ppm APT solution. Coincident increase in phosphocreatine (PCr) and a decrease in inorganic phosphate (Pi) were observed. PCr returned to the preanesthetic level when the anesthetic solution was replaced with fresh water. beta -ATP was almost unchanged during APT anesthesia.
*Descriptors:* fish physiology, animal metabolism, ATP, anaesthesia, *Cobitis biwae*


Cho G, Heath D (2000) **Comparison of tricaine methanesulphonate (MS222) and clove oil anaesthesia effects on the physiology of juvenile chinook salmon *Oncorhynchus tshawytscha* (Walbaum).** *Aquaculture Research.* 31(6):537-546
NAL Call No. SH1 F8
This study investigated the feasibility of using clove oil as an alternative to tricaine methanesulphonate as a fish anaesthetic, particularly in fish stress research. The physiological stress responses of juvenile chinook salmon *Oncorhynchus tshawytscha* (Walbaum) anaesthetized with either tricaine (50 mg/L or clove oil (20 p.p.m.) were compared using unanaesthetized fish as controls. Haematocrit, serum cortisol and serum glucose concentrations, serum lysozyme activity and differential leucocyte counts were measured from blood samples collected before, during and upon recovery from anaesthesia and at specified intervals up to 72 h after recovery. Differences between the two anaesthetic groups were not significant for most of the physiological traits measured. Serum lysozyme activity of control fish, however, was significantly suppressed relative to the treated fish for 72 h after stress. Clove oil may be a safe and cost-effective alternative to tricaine without significantly affecting study results. Furthermore, clove oil may be more practical for field-based research, because a withdrawal period is unnecessary, and clove oil does not pose an environmental hazard.
*Descriptors:* fish culture, anaesthesia, aquaculture techniques, biological stress, fish physiology, *Oncorhynchus tshawytscha*, Chinook salmon


Cho YJ, Cho MS, Kim SM, Choi YJ (1997) **Effect of anesthesia killing and non-bleeding on physicochemical properties of plaice *Paralichthys olivaceus* muscle at early period after death.** *Journal of the Korean Fisheries Society. Pusan. 30(4):589-594*
ISSN: 0374-8111
This study was performed to clarify the effect of anesthesia killing and non-bleeding on the physicochemical and rheologicai properties of plaice *Paralichthys olivaceus* muscle at early period after death. Live plaice was killed by 2 different methods: spiking at the brain instantly with bleeding or dipping in seawater containing anesthetic (2,000 ppm ethyl-aminobenzoate) for

10 min without bleeding. These samples were stored at 0°C and used in checking rigor-mortis, ATP breakdown, the content of ATP and its compounds, breaking strength, and lactate accumulation through storage. The rigor-mortis ATP breakdown, and lactate accumulation was faster in samples killed by spiking than in anesthesia. ATP in samples killed by anesthetic showed little breakdown until 22.5 hrs, but it was decomposed completely after 30 hrs storage. Breaking strength of samples killed by spiking at the brain instantly with bleeding decreased steadily and showed the maximum value over 10 hrs (2207.3 plus or minus 60.2 g). However, in the case of the dipping fresh flesh without bleeding in seawater containing anesthetic, the value and time reached around the maximum breaking strength were 2147.8 plus or minus 29.0 g and 13 hrs respectively, but it maintained constantly until 20 hrs passed. From these results it could be suggested that anesthesia killing and non-bleeding is more effective in maintaining firmness of fresh plaice muscle than spiking killing with bleeding at the early period after death.
*Descriptors:* food fish, anaesthesia, physicochemical properties, muscles, rheology, quality assurance, *Paralichthys olivaceus*, spiking, bleeding


Chung KS (1980) **Cold anaesthesia of tropical fish.** *Bulletin of the Japanese Society for Scientific Fisheries.* 46(3):391
NAL Call No. 414.9 J274
*Descriptors:* fish physiology, temperature tolerance, anaesthesia, tropical fish, cold anaesthesia.

Clark KJ (2000) **Temperature and species comparisons of benzocaine pharmacokinetics, metabolism and physiologically based pharmacokinetic model within channel catfish, *Ictalurus punctatus*, and Yellow Perch, *Perca flavescens*.** *Dissertation Abstracts International Part B: Science and Engineering.* 60(8):3880
NAL Call No. Film S-1806
Benzocaine, a local anesthetic for mammals, has potential for use as a general anesthetic in finfish. Its pharmacokinetics, metabolism, and residue profiles were characterized to support its approval in fish. To compare interspecies and temperature differences of these parameters channel catfish were studied at 16°C, 21°C, and 26°C and yellow perch at 16°C. The feasibility of "crop grouping" was investigated with a physiologically based pharmacokinetic (PBPK) model as a means to reduce the amount of testing required for aquaculture drug registration. Plasma concentration-time profiles and residue depletion profiles of benzocaine in fish tissues and fluids were characterized after fish were administered an intraarterial constant-rate infusion of 60.5 mu mol/kg benzocaine for 30 minutes. The tissue partition coefficients for benzocaine and its main metabolites were determined by fish exposed to 18.4 mu mol/L benzocaine bath for 24 hours. Benzocaine, acetylbenzocaine, p-aminobenzoic acid, and acetyl-p-aminobenzoic acid concentrations were determined by reverse isotope dilution using HPLC and LS counting. The PBPK model was comprised of seven tissue groups connected by a parallel circulatory system, in which elimination was by liver and trunk kidney metabolism, and branchial excretion. Benzocaine disappearance from plasma conformed to a two-compartment model. Comparison between benzocaine metabolic clearances and total body clearances implied that blood flow across the

gills, not metabolism, was its primary route of elimination. By 48 hours, less than 2.1% of the dose remained in the fish, of which a small percentage was in the white muscle (edible tissue). The benzocaine blood-to-water concentration ratio was 2.17-2.80 for catfish and 5.47 for perch. The magnitude of the tissue partition coefficients suggested that tissues would not retain benzocaine if elimination were perfusion rate limited. Benzocaine was 63-76% nonsaturable bound to plasma proteins. In fact the combined low affinity, high capacity and high affinity, low capacity plasma protein binding accounted for the rapid initial elimination of benzocaine followed by a longer terminal elimination. The excellent correspondence between experimental and simulated data suggested that the PBPK model was representative of the "true" physiology of fish with regard to benzocaine exposure.
*Descriptors:* fish culture, anaesthesia, toxicity tests, biodegradation, fish physiology, chemical kinetics, temperature effects, bioaccumulation, *Ictalurus punctatus*, *Perca flavescens*, channel catfish, graceful catfish, yellow perch


Cooper AR, Morris S (1998) **The blood respiratory, haematological, acid-base and ionic status of the Port Jackson shark, *Heterodontus portusjacksoni*, during recovery from anaesthesia and surgery: a comparison with sampling by direct caudal puncture.**
*Comparative Biochemistry and Physiology, A.* 119A(4):895-903
NAL Call No. QP1 C6
The effects of caudal cannulation on the blood physiology of the Port Jackson shark, *Heterodontus portusjacksoni*, were investigated in sharks given between 4 and 72 h to recover from surgery. Neither the $PaO_2$-Pv $O_2$ difference nor the $CaO_2$-$CvO_2$ difference of cannulated sharks fluctuated throughout the sampling period. The plasma acidosis exhibited 4 h after surgery was partially compensated after 24 h by a respiratory (hyperventilatory) alkalosis and after 72 h by a marked metabolic alkalosis. Whilst *H. portusjacksoni* exhibited some cell swelling after surgery the haematological status of cannulated sharks generally varied little throughout the recovery period. In contrast, marked changes in plasma and erythrocyte ion concentrations were indicative of increased branchial and erythrocyte ion permeability. The blood status of *H. portusjacksoni* given 72 h to recover from surgery was also compared with sharks sampled by caudal puncture. The respiratory and acid-base status of sharks sampled by caudal puncture was comparable to that of cannulated sharks. In contrast, the plasma ion concentrations of the cannulated sharks were markedly elevated and the erythrocyte ion concentrations concomitantly reduced when compared with punctured sharks. The apparent increase in the water and ion permeability of cannulated sharks was reflected by the reduced [Hb] and mean cell haemoglobin concentrations (MCHC). Blood sampling by caudal puncture appeared to reduce the haematological and ionic perturbations that resulted from surgery and thus provided a less invasive and reliable method for obtaining samples from 'non-disturbed' elasmobranchs.
*Descriptors:* fish physiology, anaesthesia, haematology, pH effects, biological stress, *Heterodontus portusjacksoni*, Port Jackson shark

Cubero L, Molinero A (1997) **Handling, confinement and anaesthetic exposure induces changes in the blood and tissue immune characteristics of gilthead sea bream.**
*Diseases of Aquatic Organisms.* 31(2):89-94
ISSN: 0177-5103
The gilthead sea bream *Sparus aurata* is a species of great interest for aquaculture, and in the last few years its culture has increased in the Mediterranean. This study was carried out to elucidate the mechanisms underlying the immunological response of fish after handling and confinement, procedures commonly associated with fish transport, as well as to determine the putative protective role of an anaesthetic (tricaine methanosulphonate) during confinement. Handling produces changes not only in circulating blood cells but also in the immunological cell populations of the thymus, spleen and pronephros. A stronger response in immunological cells was obtained when handling was followed by confinement. Circulating white blood cells returned to normal approximately 48 h after the onset of stress, whereas immunological tissue cells recovered later. The presence of an anaesthetic partially prevented the circulatory response, suggesting that the immunological response was less and supporting therefore the belief that the anaesthetic plays a protective role. However, it worsened the effect of handling plus confinement on haematopoietic organs, indicating that examining immunological cells in circulation only can lead to a false conclusion. Our results suggest that fish are not completely recovered until at least 144 h (6 d) after handling and transport, when cellular recovery in immunological organs occurs.
*Descriptors:* fish culture, fish handling, anaesthetics, fish physiology, haematology, leukocytes, immunity, tissues, *Sparus aurata*


Culloty SC, Mulcahy MF (1992) **An evaluation of anaesthetics for *Ostrea edulis* (L.).**
Pamaq IV: Fourth International Colloquium on Pathology in Marine Aquaculture.
*Aquaculture.* 107(2-3):249-252
NAL Call No. SH1 A6
An effective anaesthetic for oysters was sought, in order to allow for experimental manipulation of live oysters (*Ostrea edulis*) with minimal stress. A range of anaesthetic commonly used with gastropods and cephalopods, as well as a fish anaesthetic, were tested. Most of the chemicals tested were found to be unsuitable for oysters. Magnesium chloride was the most successful agent, inducing anaesthesia quickly, allowing rapid recovery with minimal stress and mortality.
*Descriptors:* anaesthesia, drugs, *Ostrea edulis*, oyster culture, pharmacology


Davidson GW, Davie PS, Young G, Fowler RT (2000) **Physiological responses of**

**rainbow trout *Oncorhynchus mykiss* to crowding and anesthesia with AQUI-S super (TM).** *Journal of the World Aquaculture Society.* 31(1):105-114
NAL Call No. SH138 W62
Following exposure to the anesthetic AQUI-S super(TM), plasma cortisol concentration in immature rainbow trout was measured as (mean) 293 plus or minus 48 ng/mL, which was significantly (P > 0.05) higher than the mean concentration in resting fish. Cortisol concentrations remained significantly (P > 0.05) elevated for at least 24 h after treatment. This was accompanied by a significant increase and decrease in hematocrit and plasma potassium, respectively. These perturbations continued for at least 48 h following recovery from anesthesia. Plasma concentrations of total protein and sodium remained unchanged following anesthesia with AQUI-S super(TM). Crowding stress is commonly encountered by fish during manipulation in aquaculture situations. Anesthetising fish prior to, and during, manipulation may reduce the associated stress. Changes in cortisol values resulting from crowding (30 min; 0.1 kg/L) during anesthesia with AQUI-S super(TM) were not appreciably different from those in fish crowded without anesthesia. Thus, anesthesia with AQUI-S super(TM) at the recommended dose of 17 mg/L did not appear to be effective for alleviating the stress of crowding under the conditions of our experiments.
*Descriptors:* fish culture, anaesthesia, fish physiology, biological stress, hormones, *Oncorhynchus mykiss*, rainbow trout


de Carvalho Gomes L (2001) **Effect of temperature on the safest level of benzocaine as an anesthetic for juveniles of *Colossoma macropomum*.** *Aquaculture 2001: Book of Abstracts.* p. 251.
Benzocaine is widely used and less expensive anesthetic for fish in Brazil. Therefore, the present investigation is to define an ideal dose of benzocaine for juveniles of *Colossoma macropomum (tambaqui)*. Fishes were exposed to various doses i.e. 50, 100, 150, 200 and 250 mg/L at different temperatures i.e. 24°C, 27°C, and 30°C and the behavioral events were taken in to consideration. In all acclimation temperatures 100 mg/L was the concentration considered ideal for quickly inducing total mobilization, attained fast recovery and safe. This concentration influence the inducing time and minimize it as the temperature rises. In this concentration, fishes may safely be exposed even for 20 minutes. Neither of the concentrations exhibited mortality while exposed at different temperatures. In contrast to other studies benzocaine is an anesthetic with a high safety margins. The fishes acclimatized at 27°C treated with 100 mg/L and exposed for 20 minutes the recovery time exposed was significantly higher than the fish exposed to anesthetic for 10 min. There were no significant differences in the recovery time at other temperatures. No mortality could be observed after 24 h of exposure for 10 or 20 min in all temperatures. Behavioral events (minutes) of *C. macropumum* juveniles exposed to Benzocaine.
*Descriptors:* temperature effects, anaesthetics, aquaculture techniques, *Colossoma macropomum*, Brazil, benzocaine, juveniles

de Carvalho Gomes L, Roubach R, Araujo-Lima CARM (2002) **Effect of density on survival and water quality for transporting *Colossoma macropomum* juveniles with $CO_2$ as an anesthetic.** *Aquaculture 2001: Book of Abstracts.* p. 252

Transportation of live fish is an essential procedure for fish culture and management. Previous studies demonstrated that the mortality of *Colossoma macropomum* juveniles decreased with the addition of $CO_2$ (50 mg/L) as an anesthetic during transportation. The aim of this paper is to verify the effect of high density on mortality and water quality during transportation with $CO_2$. Juveniles were stocked in the bags in different density (fishes/L) i. e. 30, 60, 80 and 100. $CO_2$ was added to the water by bubbling the gas. These bags were maintained for 24 h and mortality and physico-chemical parameters of water were monitored. A significant correlation between density and mortality was observed, increased the mortality with density. Transportation of *C. macropomum* without anesthetics showed a mortality rate of 10-30%. Transportation with the addition of $CO_2$ exhibited a negligible mortality at 30 fishes/L. However, 60 and 100% of mortality were recorded at 80 and 100 fishes/L. Concentrations of $CO_2$ and $O_2$ in the water with high densities were respectively high and low with the lethal range for many fish species. However no significant relation could be noticed between these parameters and the mortality rate. In spite of correlation not being observed in isolated parameters the combination of the high $CO_2$ and low $O_2$ concentrations is the most probable explanation for the mortality of fish transported in high densities. Therefore, the addition of $CO_2$ as an anesthetic in low densities (30 fishes/L) for long transportation is recommended.

*Descriptors:* water quality, aquaculture techniques, anaesthetics, carbon dioxide, dissolved oxygen, transportation, population density, survival, mortality causes, *Colossoma macropomum*, Brazil, juveniles



de M C Gontijo AM, Barreto RE, Volpato GL, Reyes VAV, Salvadori DMF (2001) **Why not anesthetize fish? In vivo and ex vivo evidence of no interference of benzocaine in the comet assay.** *Mutation Research.* 483(Supplement 1):S171

NAL Call No. QH431.M8

*Descriptors:* animal welfare, biomonitoring, fish, benzocaine, local anesthetic, alkaline comet assay, methods, blood

Deacon N, White H, Hecht T (1997) **Isolation of the effective concentration of 2-phenoxyethanol for anaesthesia in the spotted grunter, *Pomadasys commersonnii*, and its effect on growth.** *Aquarium Sciences and Conservation.* 1(1):19-27

ISSN: 1357-5325

2-Phenoxyethanol is a highly suitable anaesthetic for use with fish. This paper describes the isolation of an effective concentration of this anaesthetic for use with the spotted grunter, *Pomadasys commersonnii*. Routine anaesthesia with 2-phenoxyethanol was found to have no significant effect on the growth of this fish.
*Descriptors:* aquaculture techniques, fish culture, marine aquaculture, anaesthetics, *Pomadasys commersonnii*, growth


Derozier C (1989) **Phenoxy-2 Ethanol anaesthesia in fish.** *Thesis, Ecole Nationale Veterinaire, Nantes (France).* 100 pp.
The author studies the anaesthetic effects of phenoxy-2 ethanol in comparison with other anaesthetics utilized in aquaculture. Phenoxy-2 ethanol does not offer great advantages except for better safety, but is less expensive. Further studies must determine whether the flesh of anaesthetized fish retain phenoxyl-2 ethanol residues liable to be noxious to human health.
*Descriptors:* anaesthesia, toxicants, toxicity tests, aquaculture techniques, fish culture, Pisces, phenoxy-2 ethanol


Dick G (1973) **Some observations on the use of MS 222 Sandoz trial I.** *Scientific Report, Research and Development Department, White Fish Authority (UK).* pp. 1-7
(1) The fish are much easier caught and handled when tranquillised, they are less active and are liable to do themselves less damage in this state. (2) The fish would be less liable to stress by disturbances such as might be incurred in transportation, bumping etc., if the fish were tranquillised (3) The use of MS222 Sandoz at low concentrations of 1:75,000 and 1:100,000 would be sufficient to slow the fish down to enable catching and also to keep them tranquil during transportation for a duration of 48 hours. (4) There seems little observable difference in the effect of 1:75,000 and 1:100, 000 on the fish over 48 hours, 1:100, 000 would be cheaper. (5) To use high concentrations of 1:10,000 and 1:30,000 would be dangerous if dealing with large numbers of fish. The operation would have to be carried out swiftly as prolonged immersion has been found to be lethal after 45 minute and 9 hours respectively. At these concentration the fish would become completely anaesthetised. (6) It is felt that at a concentration of 1:50,000 over 48 hours may well have produced unmeasurable internal damage. After 22 hours, the fish seem to be fighting against the anaesthetic and kept this up for the duration of time.
*Descriptors:* MS222 Sandoz, anesthesia, stress, concentration, dosage


Durve VS (1975) **Anaesthetics in the transport of mullet seed.** *Aquaculture.* 5(1):53-63
NAL Call No. SH1 A6
The author reports the results of an investigation on the use of anaesthetics in the transportation of

live mullet seed. Experiments were carried out on 13 anaesthetics to ascertain the dosages suitable for transportation of live fish. These doses were further tested for the tolerance of mullet fry and fingerlings for a maximum period of 2 hr. Metabolism experiments were performed to find out the degree of decrease in the metabolism in terms of active $O_2$ consumption. Finally, results are given of the trial consignment despatched by rail for a transport period of 20 hr. The results indicate that out of the 13 anaesthetics tried, 7 were suitable for transportation of live fish. The relative merits and demerits of these anaesthetics are further discussed.
*Descriptors:* anaesthesia, fish culture, Mugilidae


Edwards S, Burke C, Hindrum S, Johns D (2000) **Recovery and growth effects of anaesthetic and mechanical removal on greenlip (*Haliotis laevigata*) and blacklip (*Haliotis rubra*) abalone.** *Journal of Shellfish Research.* 19(1):510
NAL Call No. SH365 A1 J6
Haliotis laevigata (39.7 plus or minus 0.2 mm, 8.2 plus or minus 0.1 g) and *Halitos rubra* (41.9 plus or minus 0.1 mm, 11.3 plus or minus 0.1 g) were acclimatised to conditions over 3-5 weeks (80 animals per 80 cm diameter fibreglass tank, flow-through sand-filtered seawater 17°C, artificial diet adlib). Animals were then removed from the tanks using ethanol (3%), 2-phenoxyethanol (1 mL/L), benzocaine (100 ppm), clove oil (0.5-1.5 mL/L) and mechanical removal (metal spatula), measured, and returned to clean water for a further six weeks. At treatment, a sample of the animals was transferred to a multichannel flow-through respirometer for analysis of oxygen uptake, which lasted at least 3 days. All treatments were duplicated for both species. One set (control) remained undisturbed from the beginning of the acclimation period to the end of the trial. Additional respirometry trials were conducted on the same cohorts for KCl (10 g/L), Aqui-S (50 ppm) and Tabasco (10 ml/L) that didn't fit in the growth trial. Apart from first hour suppression (ethanol) or stimulation (clove oil & Aqui-S) of oxygen uptake, most agents showed shifted normal patterns of oxygen uptake settling to a normal value ( similar to 55 mg $O_2$ times kg/h) over 3-5 days. Increases in oxygen uptake were seen in first day averages for clove oil (156%), Aqui-S (154%) and KCl (127%). Mechanical removal gave first day suppression (50%) of oxygen usage, returning to normal with the evening activity cycle. Tabasco treated animals took longest to recover from a suppression of oxygen uptake. Benzocaine and KCl treated animals recovered most rapidly. There was no apparent recovery from clove oil in the time period studied. Growth trials showed healthy growth rates for control *H. laevigata* (116 plus or minus 3 mu m, 78 plus or minus 4 mg per day) and all treatments indicated a suppression of growth rate as a result of removal from the tanks (48-83 mu m, 19-70 mg per day). For *H. rubra*, control growth rates were much lower (24 plus or minus 1 mu m/ day) and weight gain was erratic (34 plus or minus 10 mg/day). Nonetheless, lower growth rates (length 1.4-12.1 mu m/day) were obtained for all treatments, while all but one treatment also had lower weight gain than control animals. Animals subjected to clove oil

had the lowest weight gain and this was the only treatment that resulted in significant mortalities.
*Descriptors:* fish diseases, mollusc culture, anaesthesia, disease control, *Haliotis laevigata*, *Haliotis rubra*


Erdmann MV (1999) **Clove oil: an 'eco-friendly' alternative to cyanide use in the live reef fish industry?** *Live Reef Fish Information Buletin.* 5:4-7
ISSN: 1026-2040
The use of clove oil in aquarium trade has been a new idea in Indonesia. The author reviews the use and anaesthetic effects of clove oil. He explains the possible use in live reef fish trade. The use of cyanide is fishing is very damaging to the marine environment, hence a possible alternative - clove oil as anaesthetic for wild capture, handling and transport of live fish.
*Descriptors:* ornamental fish, stupefying methods, fish poisoning, trade, cyanides, live storage, transportation, aquaria, clove oil


Etienne T (1989) **Fish anaesthesia.** *Thesis, Ecole Nationale Veterinaire, Nantes (France).* 71 pp
After a brief review of physiological and anatomical particularities of fish, the author presents the various methods of chemical and physical anaesthesia: (anaesthetics, electronarcosis, hypothermia).
*Descriptors:* anaesthesia, aquaculture techniques, fish culture, fish physiology, literature reviews, Pisces


Falls WW, Vermeer GK, Dennis CW (1988) **Evaluation of etomidate as an anesthetic for red drum, *Sciaenops ocellatus*.** Red Drum Aquaculture. Proceedings of aSymposium on the Culture of Red Drum and Other Warm Water Fishes.*Contributions in Marine Science.* 30 (suppl):37-42
NAL Call No. 442.9 T31
Etomidate was evaluated as an anesthetic in fourteen female and seven male red drum. Fish were anesthetized every 2 or 3 weeks with etomidate dosage levels of 0.8, 1.6, or 8.0 mg/L during a pre-spawning conditioning regime. The 8 mg/L dosage was found to be too high as fish reached stage 4 anesthesia (loss of reflex activity) in less than 30 sec. At a 0.8 mg/L dosage, mean induction and recovery times were excessively long. Further trials at these 2 dosages were discontinued. Between the induction and recovery periods, fish were maintained in a respirator at a 0.4 mg etomidate/L dosage for a mean time of 17.47 min. An induction dose of 1.6 mg/L and a respirator maintenance dose of 0.4 mg/L appeared suitable for routine fish handling.
*Descriptors:* anaesthetics, fish handling, *Sciaenops ocellatus*, aquaculture techniques

Farwell CJ (1978) **The use of the fish anesthetic quinaldine at Scripps aquarium-museum.** *Annual Proceedings of the American Association of Zoologists and Parks Aquarists.* 61-71

The use of an anaesthetic such as quinaldine when removing fish from a display tank not only simplifies the job, but helps in lowering the chances of damaging and stressing the fish that can lead to future health problems. The amount of quinaldine needed is determined by tank volume and the final concentration required and the stages of anaesthesia observed in the fish are first irritation or hyperactivity, which is quickly followed by a loss and then a total loss of equilibrium. At this point a high respiratory rate that is weak and interrupted by gasps is apparent. The fish are relatively still and can be handled without struggling. The fish recover quickly from the effects.

*Descriptors:* aquaria, ornamental fish, anaesthetics, fish handling



Ferck BJ, Jameson JD, Ramadhas V (1996) **Carbonic acid as an anaesthetic in the transport of fishes.** *Water Quality Issues in Aquaculture. Proceedings of the National Seminar on Water Quality Issues in Aquaculture Systems, Dec. 18 and 19, 1996.* pp. 103-108.

Fish seed and broodfish usable in fish farming or for sale need to be transported in live condition which may involve considerable time and distance. In this connection, their packing with anaesthetics is indispensable. The present investigation was undertaken to determine the safer limit of carbonic acid as an aneasthetic for the the transport of fry of 4 species of ornamental fishes viz. *Gymnocorymbus ternetzi, Mollienesia latipinna, Carassius auratus* and *Xiphophorus helleri.* The fish fry of these species were sedated with carbonic acid in 50, 100, 150 and 200 ppm concentrations with and without oxygen. Periods for indiction, recovery and death were recorded simultaneously for all the species. An extremely low induction time of 13.3 seconds at 200 ppm carbonic acid was recorded for *G. ternetzi* and *M. latipinna* and a high recovery time of 187-195 seconds of *X. helleri* and *M. latipinna*, *C. auratus* and *G. ternetzi* exhibited 80-100% survival in all the concentration of carbonic acid. The technology of packing commercially important fishes using the above anaesthetic is also discussed in detail.

*Descriptors:* ornamental fish, anaesthetics, carbonic acid, *Gymnocorymbus ternetzi, Mollienesia latipinna, Carassius auratus, Xiphophorus helleri*, transportation, oxygen consumption, survival, green swordtail



Ferreira JT, Schoonbee HJ, Smit GL (1984) **The anaesthetic potency of benzocaine-hydrochloride in three freshwater fish species.** *South African journal of Zoology = Suid-Afrikaanse Tydskrif vir Dierkunde.* 19(1):46-50

NAL Call No. QL336 Z6
Anaesthesia was induced in the common carp, *Cyprinus carpio*, tilapia, *Oreochromis mossambicus* and rainbow trout, *Salmo gairdneri*, at concentrations of 25; 50; 75 and 100 mg/l of benzocaine-hydrochloride as well as neutralized benzocaine-hydrochloride at water temperatures of 15º; 20º and 25º. The results obtained indicated intra- and interspecific differences in the susceptibility of fish to anaesthesia due to metabolic, chemoreceptive and temperature tolerance differences in and amongst the three species.
*Descriptors:* anesthetics, performance assessment, *Cyprinus carpio, Oreochromis mossambicus, Salmo gairdneri*, benzocaine-hydrochloride


Ferreira JT, Schoonbee HJ, Smit GL (1984) **The use of benzocaine-hydrochloride as an aid in the transport of fish.** *Aquaculture.* 42(2):169-174
NAL Call No. SHI A6
The potential of benzocaine-hydrochloride as an aid in the transport of fish was investigated. When used at a concentration of 25 mg/l the anaesthetic caused a reduction in the excretion of ammonia and carbon dioxide by the fish, while, as a result of the reduced activities of the fish, the pH and alkalinity values of the transport water remained fairly constant. When benzocaine-hydrochloride was not used, the activities of the fish produced a significant deterioration in water quality evidenced by the accumulation of ammonia and carbon dioxide.
*Descriptors:* fish handling, transportation, anesthetics, aquaculture, ethyl aminobenzoate hydrochloride, Pisces, benzocaine-hydrochloride


Ferreira JT, Schoonbee HJ, Smit L (1984) **The uptake of the anaesthetic benzocaine hydrochloride by the gills and the skin of three freshwater fish species.** *Journal of Fish Biology.* 25(1):35-41
NAL Call No. QL614 J68
The uptake of benzocaine hydrochloride and neutralized benzocaine hydrochloride by the skin and the gills of *Cyprinus carpio*, *Oreochromis mossambicus* and *Salmo gairdneri* were studied. The differences observed can mainly be ascribed to degree of ionization and the lipid solubility of the anaesthetic.
*Descriptors:* anesthetics, gills, skin, pharmacology, *Cyprinus carpio, Oreochromis mossambicus, Salmo gairdneri*, benzocaine hydrochloride


Ferreira JT, Smit GL, Schoonbee HJ (1981) **Haematological evaluation of the anaesthetic benzocaine hydrochloride in the freshwater fish *Cyprinus carpio* L.** *Journal of Fish Biology.* 18(3):291-297
NAL Call No. QL614 J68
The effects of anaesthetization with different concentrations of benzocaine hydrochloride (BH)

and neutralized benzocaine hydrochloride (NBH) were studied on the haematology of *C. carpio*. Due to its acidic nature and resultant effects on aquarium water, BH produces haemoconcentration effects with disturbances in acid-base function. The use of NBH, whereby water quality effects were drastically reduced, improved the general haematological profile. In contrast, haemodilution resulted when blood was sampled without the use of an anaesthetic agent.
*Descriptors:* anaesthetics, haematology, *Cyprinus carpio*, Cyprinidae, Pisces


Ferreira JT, Smit GL, Schoonbee HJ, Holzapfel CW (1979) **Comparison of anesthetic potency of benzocaine hydrochloride and MS-222 in two freshwater fish species.** *Progressive Fish Culturist.* 41(3):161-163
NAL Call No. 157.5 P94
The hydrochloride of ethyl p-aminobenzoate was synthesized and its anesthetic potency compared with that of MS-222 at concentrations of 50, 80, and 100 mg/l. The free compound of these agents in fish blood was also determined. The results indicate that benzocaine hydrochloride is a more effective anesthetic than MS-222 at the concentrations applied. Benzocaine hydrochloride is not registered for fishery use in the United States.
*Descriptors:* anaesthetics, freshwater fish, *Cyprinus carpio, Sarotherodon mossambicus*, Cyprinidae, Pisces, Cichlidae


Gerwick L, Demers NE, Bayne CJ (1999) **Modulation of stress hormones in rainbow trout by means of anesthesia, sensory deprivation and receptor blockade.** *Comparative Biochemistry and Physiology, A.* 124A(3):329-334
NAL Call No. QP1 C6
Sympathetic activation leading to increased levels of blood catecholamines, and stimulation of the hypothalamic-pituitary-inter-renal axis leading to increased cortisol, are difficult to avoid when handling animals. Yet, in research on effects of acute stress, elicitation of such responses must be minimized in the control groups. The work examines means to achieve a minimally disturbed state in rainbow trout (*Oncorhynchus mykiss*). Level of arousal was determined by adrenaline and cortisol concentrations in plasma, and by the spleen:somatic index. Fish were prepared for bleeding by rapid capture and concussion, by infusion of anesthetic into the undisturbed home tank, by confinement in black boxes, or by being fed alpha - and beta -receptor antagonists. Even when done quickly, netting and concussion yielded fish with ca. 200-pmol adrenaline/ml plasma. Cortisol was elevated (to > 10 ng/ml) within 30 s of stress initiation. Surreptitious infusion of anesthetic (2-phenoxyethanol, PE) into tanks yielded fish with lower adrenaline levels (means 19.34 and 19.58 pmols/ml in home tank and black boxes, respectively). Among fish given phentolamine and propranolol, spleen:somatic indices and plasma adrenaline were higher than in diet controls, whether undisturbed or stressed, indicative of successful receptor blockade. Since careful infusion of 2-PE yielded the lowest adrenaline levels, and requires no special

apparatus, it is the method of choice for obtaining minimally stressed fish.
*Descriptors:* biological stress, fish handling, hormones, anaesthetics, therapy, fish culture, drugs, serological studies, endocrinology, aquaculture techniques, anaesthesia, *Oncorhynchus mykiss*, rainbow trout


Ghion F (1975) **First promising results in the use of Fluothane as general anesthetic for fish.** *Italian Review of Fish Culture and Fish Pathology.* 10(4):111-112
NAL Call No. SH1 R5
Fluothane (2-bromo-2-chloro-1, 1, 1, -trifluoro-ethane) a general anesthetic for humans, has been tested on euryhaline fish (*Dicentrarchus labrax, Sparus auratus, Mugil cephalus*) with promising results. The anaesthetic is bubbled into the water mixed with air and its delivery is stopped when fish start to swim erratically. Narcosis was always attained within 10 min from the beginning of anaesthesia. Fish recovery rapidly occurred when pure air was bubbled into the aquarium. Fish were safely exposed to the anaesthetic for times ranging up to 8 h. Gross evaluation of Fluothane concs inducing immediate narcosis gave values {approx} 40 ppm.
*Descriptors:* anaesthesia, *Dicentrarchus labrax, Sparus aurata, Mugil cephalus*


Gilderhus PA (1990) **Benzocaine as a fish anesthetic: Efficacy and safety for spawning-phase salmon.** *Progressive Fish Culturist.* 52(3):189-191
NAL Call No. 157.5 P94
The anesthetic benzocaine was tested for efficacy and safety for spawning-phase chinook salmon (*Oncorhynchus tshawytscha*) and Atlantic salmon (*Salmo salar*) at federal fish hatcheries. Benzocaine concentrations of 25-30 mg/L anesthetized most fish in less than 3.5 min, and most fish recovered in less than 10 min after 15 min of exposure. Safety margins were narrow; both species tolerated 30 mg/L for about 20 min, but 25 min of exposure caused deaths. For 15-min exposures, concentrations of 35 mg/L for chinook salmon and 40 mg/L for Atlantic salmon were lethal.
*Descriptors:* fish culture, hatcheries, anaesthetics, toxicity tolerance, *Oncorhynchus tshawytscha*, *Salmo salar*, spawning, benzocaine


Gilderhus PA, Lemm CA, Woods LC III (1991) **Benzocaine as an anesthetic for striped bass.** *Progressive Fish Culturist.* 53(2):105-107
NAL Call No. 157.5 P94
Benzocaine was tested as an anesthetic on juvenile and mature adult striped bass (*Morone saxatilis*). Concentrations of 55 mg/L at 22°C to 80 mg/L at 11°C effectively anesthetized fish in about 3 min. Recovery was more rapid as temperature increased. Fish survived concentrations of twice the effective concentration and exposure times up to 60 min at the effective concentration. Striped bass required higher concentrations for anesthetization than

had been previously demonstrated for salmonid fishes, but safety margins for both concentration and exposure time were wider than for the salmonids.
*Descriptors:* anaesthetics, efficiency, recovery, temperature effects, *Morone saxatilis*, fish culture, benzocaine


Gingerich WH, Drottar KR (1989) **Plasma catecholamine concentrations in rainbow trout (*Salmo gairdneri*) at rest and after anesthesia and surgery.** *General and Comparative Endocrinology.* 73(3):390-397
NAL Call No. 444.8 G28
The effects of surgery and anesthesia on concentrations of plasma epinephrine (E), norepinephrine (NE), and dopamine (DA) were investigated in rainbow trout (*Salmo gairdneri*) fitted with dorsal aorta cannulae. Baseline catecholamines (CA) concentrations, established in resting rainbow trout, were 1.55 plus or minus 0.90 rho mol/ml (X plus or minus SD) for E, 2.07 plus or minus 1.26 for NE, and 1.33 plus or minus 0.87 for DA. After surgery, plasma concentrations of all CAs fell rapidly but values were still higher than baseline 6 hr after surgery, then were near baseline at 24 and 48 hr after surgery. Plasma E and NE concentrations in the fish during early anesthesia (1.14 plus or minus 0.14 min) were not significantly different from preanesthesia values.
*Descriptors:* blood, hormones, anaesthesia, biological stress, steroids, fish physiology, *Salmo gairdneri*, serological studies


Gleadall IG (1991) **Comparison of anaesthetics for octopuses.** *Bulletin of Marine Science.* 49(1-2):663
ISSN: 0007-4977
This study, comparing eleven different immersion anaesthetics for octopuses, was initiated in view of the failure of conventional ethanol or urethane anaesthesia of octopuses at lower temperatures (< 12°C), 2) a requirement for better fine control over anaesthesia, and, a reluctance to use magnesium chloride anaesthesis for certain experiments. A standard procedure was adopted to compare the three well established anaesthetics (ethanol, urethane, magnesium chloride) with several well known fish anaesthetics (tricaine, metomidate, propoxate) and those commonly employed with invertebrates (chloral hydrate, chloretone, menthol, nicotine sulphate, phenoxetol). Also, two methods of anaesthesia by cooling are briefly compared. The species used were mostly *Octopus vulgaris* and *O. fang-siao* (but also included *O. dofleini* and *Octopus sp.*, with doses carefully adjusted for body weight; three different doses were used within the recommended range for each anaesthetic. Most "invertebrate" and "fish" anaesthetics either failed to anaesthetize the octopuses (at low doses) or they proved toxic or fatal (at higher doses), with no intermediate anaesthetic effect. Effective anaesthetics are used for different types of experimentary, but the search continues for a more finely controllable, all-round anaesthetic for octopuses.
*Descriptors:* temperature effects, Octopoda, comparative studies, anaesthetics

Gomes LC, Chippari-Gomes AR, Lopes NP, Roubach R, Araujo-Lima CARM (2001) **Efficacy of Benzocaine as an Anesthetic in Juvenile Tambaqui *Colossoma macropomum*.** *Journal of the World Aquaculture Society.* 32(4):426-431
NAL Call No. SH138 W62
The present study investigated the use of benzocaine as an anesthetic for juvenile *Colossoma macropomum (tambaqui)*. In the first experiment, fish were exposed to various doses of benzocaine for 10 min at 24ºC. The second experiment examined the effects of duration of exposure to 100 mg/L of benzocaine. In the third experiment, fish were exposed to 100 mg/L at temperatures of 24ºC , 27ºC, and 30ºC. Benzocaine concentrations of 100-150 mg/L were considered ideal for quickly inducing total immobilization and fast recovery. Fish exposed to 350 mg/L benzocaine exhibited 30% mortality. No changes in hematocrit were recorded in fish exposed to different concentrations of benzocaine. Plasma glucose increased significantly when fish were exposed to benzocaine concentrations greater than 200 mg/L. Recovery time after a 30-min exposure to 100 mg/L benzocaine was significantly greater than after an exposure for 10 and 20 min. No mortality was observed 96 h after exposure to 100 mg/L benzocaine for 10, 20, and 30 min. Dosages in the 100-150 mg/L range were effective for periods of up to 20 min of anesthesia. There was no effect of temperature on the time required for fish to lose equilibrium. However, recovery was significantly faster for fish anesthetized at 30ºC. Benzocaine is an effective anesthetic agent for tambaqui juveniles, providing rapid immobilization and rapid recovery. Benzocaine is also less expensive than other available anesthetic compounds.
*Descriptors:* juveniles, experimental research, costs, anaesthetics, *Colossoma macropomum*, benzocaine


Graham MS, Iwama GK (1990) **The physiologic effects of the anesthetic ketamine hydrochloride on two salmonid species.** *Aquaculture* 90(3-4):323-331
NAL Call No. SH1A6
Adult coho salmon (*Oncorhynchus kisutch*) and subadult rainbow trout (*Oncorhynchus mykiss*) were used in experiments with the anesthetic ketamine hydrochloride. The drug (30 mg/kg) was injected into the dorsal aorta through an indwelling cannula. Intravascular administration of ketamine caused an immediate cessation of ventilation in both species for 10 s to 300 s and a loss of balance. Ventilation rate recovered to pre-anesthesia values within 1-2 h and arterial oxygen values were at pre-anesthesia levels by 3-24 h. Anesthesia caused a significant acidosis in both species. The blood pH and plasma $CO_2$ values had returned to pre-anesthesia levels by 4-24 h and 0.5-2 h, respectively. For adult salmon, five of seven animals were unresponsive to tail grabbing at 4 h while with juvenile trout, three of five fish were fully responsive to touch at 1 to 2 h. This difference in duration of anesthesia was likely size-related. The applications of this injectable anesthetic for commercial fish use, mainly in the transport of animals, are suggested, but its use with food fish has not been assessed.
*Descriptors:* anaesthetics, aquaculture techniques, cultured organisms, transport, *Oncorhynchus*

*mykiss, Oncorhynchus kisutch*, ketamine hydrochloride


Guidobono F, Netti C, Sibilia V, Villa I, Zamboni A, Pecile A (1986) **Eel calcitonin binding site distribution and antinociceptive activity in rats.** *Peptides* 7(2):315-322
NAL Call No. QP552 P4P45
The distribution of binding sites for ($^{125}$I)-eel-calcitonin (ECT) to rat central nervous system, studied by an autoradiographic technique, showed concentrations of binding in the diencephalon, the brain stem and the spinal cord. Large accumulations of grains were seen in the hypothalamus, the amygdala, in the fasciculus medialis prosencephali, in the fasciculus longitudinalis medialis, in the ventrolateral part of the periventricular gray matter, in the lemniscus medialis and in the raphe nuclei. In the spinal cord, grains were scattered throughout the dorsal horns. Binding of the ligand was displaced equally by cold ECT and by salmon CT(sCT), indicating that both peptides bind to the same receptors. The administration of ECT into the brain ventricles of rats dose-dependently induced a significant and long-lasting enhancement of hot-plate latencies comparable with that obtained with sCT. The antinociceptive activity induced by ECT is compatible with the topographical distribution of binding sites for the peptide and is a further indication that fish CTs are active in the mammalian brain.
*Descriptors:* calcitonin, central nervous system, intracerebroventricular administration, analgesia, fish physiology, peptides, brain, Anguilla, binding, autoradiography, distribution, rats, neurophysiology


Guo FC, Teo LH, Chen TW (1995) **Effects of anaesthetics on the oxygen consumption rates of platyfish *Xiphophorus maculatus* (Guenther).** *Aquaculture Research.* 26(12):887-894
NAL Call No. SH1 F8
This study was carried out to find out the effects of anaesthetics, 2-phenoxyethanol, quinaldine sulphate, MS-222 and metomidate, at various dosages, on the oxygen consumption rates of two size groups of platyfish, *Xiphophorus maculatus* (Guenther) at three temperatures. The results show that the oxygen consumption by the platyfish of both size groups was temperature dependent, being higher at higher temperature, but not size dependent. The effects of anaesthetics on the oxygen consumption rates of platyfish were dosage dependent and temperature dependent, especially for 2-phenoxyethanol, the effect always being significantly greater at lower temperature. Small and large fish did not show much difference in their responses to anaesthetic treatments. However, with 2-phenoxyethanol, the effect on the large platyfish was always better than on the small ones at 20-25°C. At 220-440 ppm and at 20°C, 2-phenoxyethanol was more effective than the other anaesthetics in suppressing oxygen consumption by the platyfish.
*Descriptors:* anaesthetics, temperature effects, *Xiphophorus maculatus*, oxygen consumption, ornamental fish, aquaria

Guo FC, Teo L-H, Chen TW (1995) **Effects of anaesthetics on the water parameters in a simulated transport experiment of platyfish, *Xiphophorus maculatus* (Guenther).** *Aquaculture Research.* 26(4):265-271
NAL Call No. SH1 F8
An experiment was carried out to study the effects of anaesthetics (2-phenoxyethanol, quinaldine sulphate, metomedate and MS-222) on water parameters during simulated air transport of platyfish, *Xiphophorus maculatus*. The platyfish were put in sealed plastic bags, one-quarter full of water, to which a required amount of anaesthetic was added. The rest of the bag was filled with oxygen. The water in the bag was tested for pH, total ammonia and carbon dioxide at intervals of 4 and 8 h for a period of 48 h. Mortality rates within this period and the post-packaging period were also noted. It was found that 2-phenoxyethanol was most effective, followed by quinaldine sulphate, in decreasing the excretion of metabolic wastes by the fish. Metomidate had no effect in the control of waste production. MS-222 reduced ammonia excretion but not carbon dioxide. None of the anaesthetics used had any effect on the pH of the water.
*Descriptors:* *Xiphophorus maculatus*, oxygen consumption, anaesthetics, fish physiology, excretion


Hanawa M, Harris L, Graham M, Farrell AP, Bendell-Young LI (1988) **Effects of cyanide exposure on Dascyllus aruanus, a tropical marine fish species: lethality, anaesthesia and physiological effects.** *Aquarium Sciences and Conservation. 2(1):21-34*
ISSN: 1357-5325
The lethality, anaesthetic and physiological effects of ‘pulsed’ cyanide ($CN^-$) exposures to a common tropical marine fish *Dascyllus aruanus* were assessed. Cyanide (25 and 50 mg/l) was applied as pulses (10, 60 and 120 s) to fish under non-stressed and stressed (by chasing and/or placing fish under hypoxic stress) conditions. Following treatment, the time until recovery and the percent survival were determined. The fish were allowed a 2.5 week recovery period from the treatments at which time four physiological end-points were measured: (1) the blood haemoglobin content, (2) the percent blood $O^2$ content, (3) the liver rhodonase activity and (4) the liver $O^2$ consumption rate. The greater the $CN^-$ concentration and exposure time, the longer the recovery time.
*Descriptors:* oxygen consumption, liver, biological stress, cyanides, marine fish, tropical fish, fish physiology, anaesthetics, *Dascyllus aruanus*, physiology, cyanide,


Harrell RM (1992) **Stress mitigation by use of salt and anesthetic for wild striped bass captured for brood stock.** *Progressive Fish Culturist.* 54(4):228-233
NAL Call No. 157.5 P94

Gravid striped bass (*Morone saxatilis*) were collected from spawning grounds of the Choptank River, Maryland, to evaluate ways of mitigating stress effects associated with capture and transport. Stress alleviation was attempted through the use of salt (10 g/L), anesthetic (tricaine (MS-222) at 25 mg/L), or a combination of the two. Two capture techniques were used, electrofishing and gill netting, and all captured fish were immediately placed in tanks with the respective treatment then transported by truck to the hatchery. Fish stress was measured by plasma corticosteroid and chloride levels. The times required for stressed fish to recover, as measured by a return to baseline values of plasma corticosteroids, indicated that stress was mitigated most effectively by salt alone. The combination of salt and anesthetic was second in effectiveness, and the anesthetic alone was least effective. Although fish in each treatment initially exhibited signs of hypochloremia, only those fish transported in anesthetic along exhibited long-term signs of hypochloremia regardless of capture method.
*Descriptors:* biological stress, anaesthetics, *Morone saxatilis*, salts, fish handling, fish culture


Hattingh J (1977) **The effect of tricaine methanesulphonate (MS-222) on the microhaematocrit of fish blood.** *Journal of Fish Biology.* 10(5):453-455
NAL Call No. QL614 J68
The effects of the anaesthetic, MS-222, on the microhaematocrit value of freshwater fish have been examined. Blood containing MS-222 showed a higher haematocrit value than blood without the anaesthetic and haemolysis occurred in the former after a variable time depending on the concn. The results are discussed in relation to previous findings.
*Descriptors:* serological studies, anaesthetics, Pisces


Hettiarachchi M, Senadheera SPSD (1999) **Efficacy of quinaldine sulphate as an anaesthetic for the ornamental carp (*Cyprinus carpio*) in simulated packaging for long distance transport.** *Sri Lanka Journal of Aquatic Sciences.* 4:13-22
ISSN: 1391-2038
The high cost incurred in transporting fish in large volumes of water is a major problem in airlifting ornamental fish to foreign markets. The present study was carried out to investigate the efficacy of the anaesthetic, quinaldine sulphate buffered with sodium bicarbonate on ornamental carps (Koi carps, *Cyprinus carpio*) in simulated packaging for air transport. Quinaldine sulphate significantly reduced the rate of oxygen consumption and the accumulation of ammonia in water. The most efficient concentration of buffered quinaldine sulphate which was responsible for the greatest reduction in accumulation of ammonia and the rate of oxygen consumption was 50 ppm. Young koi carps of 7.5-9.0 cm in total length anaesthetised with 50 ppm quinaldine sulphate at the density of 40% of fish body weight to weight of water ratio did not show any mortality at room temperature of 28°C during the 40 hours of exposure time while unanaesthetized fish at the same

density suffered 100% mortality. The recovery time during the post-packaging period was found to be less than 5 minutes. The present study indicates that young koi carps could be transported at higher packing densities, using the suitable dosage of quinaldine sulphate which will maximize the effective utilization of space and weight during transportation.
*Descriptors:* anaesthetics, live storage, transportation, ornamental fish, survival, *Cyprinus carpio*, common carp


Hignette M (1984) **The use of cyanide to catch tropical marine fish for aquariums and its diagnosis.** *Comptes Rendus des Journees Aquariologiques de l'Institut Oceanographique, 16 Dec 198 (Proceedings of Marine Aquariology of the Oceanographical Institute, 16 Dec 1983.). Oceanis. Serie de documents oceanographiques. Paris.* 10(5):585-591
ISSN: 0182-0745
Marine tropical fish for the pet industry are nowadays very often caught with cyanide sodium, which is used for its “anaesthetic” effect. This method however can be responsible for fish dying as much as several weeks after transport, and must be avoided. In order to stop exporters having recourse to this practice, fish importers and aquariologists must know how to measure cyanide themselves in fish or obtain analyses from reliable laboratories.
*Descriptors:* cyanides, aquaria, tropical fish, catching methods, fish poisoning, stupefying methods, mortality causes


Hirata M, Isoda S, Kanao M, Shimizu H, Inoue S (1970) **Studies on anesthetics for fish.** *Bulletin of the Japanese Society for Scientific Fisheries* 36(11):1127-1135
NAL Call No. 414.9 J274
92 anthranilate derivatives were synthesized and examined for their anaesthetic effect on Carassius and puffer. Compound No. 36, DP-1166, was the most potent anaesthetic for these fish and also showed excellent effectiveness on other spp.

*Descriptors:* anesthetics, DP-1166, Carassius, puffer, anthranilate derivatives

Hoffmann R, Lommel R, Riedl M (1982) **Influence of different anaethetics and bleeding methods on hematological values in fish.** *Archiv fur Fischereiwissenschaft.* 33(1-2):91-103
NAL Call No. SH1 A72
Erythrocyte, leucocyte and thrombocyte values, hemoglobin, PCV and differential blood cell counts were investigated in a cyprinid (*Carassius carassius* L.) and in a salmonid (*Salmo gairdneri* Richardson) fish using two different methods of blood sampling and four methods of anaesthesia. Whereas red blood cell and thrombocyte values were significantly altered both by anaesthesia and method of bleeding, such an influence could not be proved in leucocyte values.

*Descriptors:* anesthetics, blood cells, hematology, methodology, *Carassius carassius, Salmo gairdneri*


Houston AH, Corlett JT (1976) **Specimen weight and M.S. 222.** *Journal of the Fisheries Research Board of Canada.* 33(6):1403-1407
NAL Call No. 442.9 C16J
The influence of specimen wt upon induction of and recovery from Stage I M. S. 222 (ethyl m-aminobenzoate methanesulphonate) was examined in gold-fish (*Carassius auratus*), brook (*Salvelinus fontinalis*), and rainbow trout (*Salmo gairdneri*) exposed to various anesthetic concn-temp combinations. Both induction and recovery times varied inversely with wt, the influence of wt being particularly pronounced among smaller specimens. These observations are consistent with the hypothesis that attainment of 'critical' internal anesthetic concn is influenced by wt-specific variation in the relationship between gill area and extracellular phase vol.
*Descriptors:* anaesthetics, *Carassius auratus, Salvelinus fontinalis, Oncorhynchus mykiss*


Hovda J, Linley TJ (2000) **The potential application of hypothermia for anesthesia in adult Pacific salmon.** *North American Journal of Aquaculture.* 62(1):67-72
NAL Call No. SH1 N66
We subjected 190 adult pink salmon *Oncorhynchus gorbuscha* to water temperatures of -1.5, -3.0° C, -4.5°C, and -6.0°C to evaluate the potential of hypothermia for anesthesia. The temperatures were obtained by dissolving salt (NaCl) at concentrations ranging from 25ppt to 90ppt and recirculating the solutions through a thermostatically controlled chiller. The time to each anesthetic stage (sluggishness, loss of movement, and complete anesthesia) declined with decreasing temperature but did not differ significantly between sexes. The most rapid change in response occurred between -1.5°C and -3.0°C. Time to recovery was also influenced by temperature and was directly related to the time to complete anesthesia. In contrast, anesthesia temperature had no affect on egg survival, nor was there a significant difference in survival between the experimental groups and the control ($CO^2$). We conclude that hypothermia is effective for short-term anesthesia of Pacific salmon *Oncorhynchus spp.* for spawning but note that its application for iteroparous or freshwater stenohaline species may be problematic because of the physiological effects induced by cold shock and exposure to high salinity. Further work will also be needed to determine its utility for large-scale operation.
*Descriptors:* temperature tolerance, hypothermia, fish culture, survival, anaesthesia, *Oncorhynchus gorbuscha*, pink salmon


Howe GE, Bills TD, Marking LL (1990) **Removal of benzocaine from water by filtration with activated carbon.** *Progressive Fish Culturist.* 52(1):32-35

NAL Call No. 157.5 P94

Benzocaine is a promising candidate for registration with the U.S. Food and Drug Administration for use as an anesthetic in fish culture, management, and research. A method for the removal of benzocaine from hatchery effluents could speed registration of this drug by eliminating requirements for data on its residues, tolerances, detoxification, and environmental hazards. Carbon filtration effectively removes many organic compounds from water. This study tested the effectiveness of three types of activated carbon for removing benzocaine from water by column filtration under controlled laboratory conditions. An adsorptive capacity was calculated for each type of activated carbon. Filtrasorb 400 (12 x 40 mesh; U.S. standard sieve series) showed the greatest capacity for benzocaine adsorption (76.12 mg benzocaine/g carbon); Filtrasorb 300 (8 x 30 mesh) ranked next (31.93 mg/g); and Filtrasorb 816 (8 x 16 mesh) absorbed the least (1.0 mg/g). Increased adsorptive capacity was associated with smaller carbon particle size; however, smaller particle size also impeded column flow. Carbon filtration is a practical means for removing benzocaine from treated water.

*Descriptors:* water filtration, anaesthetics, aquaculture effluents, wastewater treatment, water quality control, hatcheries, biofilters, water quality, aquiculture, activated carbon, effluent treatment, water treatment, filtration, benzocaine, activated carbon



Hseu JR, Yeh SL, Chu YT, Ting YY (1995) **Application of sodium bicarbonate and sulfuric acid for anesthetization of black porgy *Acanthopagrus schlegeli*.** *Journal of Taiwan Fisheries Research.* 3(2):151-159

NAL Call No. SH1 S48

Solutions of sodium bicarbonate ($NaHCO_3$) and sulphuric acid ($H_2SO_4$) were mixed in seawater to try to anesthetize black porgy (Acanthopagrus schlegeli). The results indicated that the anesthetic induction time was correlated positively with body size and negatively with the concentration of $NaHCO_3$ and $H_2SO_4$, but only the concentration influenced the recovery time. 675 ppm $NaHCO_3$, mixed with 395 ppm $H_2SO_4$, might be suitable to anesthetize black porgy because the induction time and the recovery time of most of the fish were less than 6 minutes at this concentration. No fish died during anesthetization and 5 days thereafter. Thus, this technique should be effective and safe for anesthetization of black porgy. An examination was also made of the changes of the physiological parameters of black porgy after anesthetization by 675 ppm $NaHCO_3$, mixed with 395 ppm $H_2SO_4$. The values of hematocrit, hemoglobin, plasma glucose, and total plasma protein were not significantly different between the anesthesia and the control groups. However, the plasma chloride ion concentration decreased significantly and the osmolarity increased significantly after anesthetization.

*Descriptors:* anaesthesia, sulphuric acid, fish physiology, *Acanthopagrus schlegeli*, methodology, sodium bicarbonate

Hseu Jinn-Rong, Yeh Shinn-Lih, Chu Yeong-Torng, Ting Yun-Yuan (1996) **Influence of the anesthetic, 2-phenoxyethanol, on hematological parameters of black porgy *Acanthopagrus schlegeli*.** *Journal of Taiwan Fisheries Research.* 4(2):127-132
NAL Call No. SH1 S48
In this study, an examination was made of changes of hematological parameters in black porgy *Acanthopagrus schlegeli* after anesthetization in 2-phenoxyethanol (2-PE) of various concentrations. In 400 and 600 ppm 2-PE solutions, black porgies were anesthetized to total loss of equilibrium within 3 min. All values of hematological parameters of the anesthetized fishes were not significantly different between the anesthesia and control groups. In 200 ppm 2-PE solution, since the fish could not be anesthetized to total loss of equilibrium within 30 min, the black porgies which were anesthetized for 15 min in this solution were tested and it was found that the fish showed a significant decrease in hematocrit and increase in plasma glucose. It is therefore concluded that higher dosages of 2-PE will take less time to induce less stress effect on the anesthetized fish.
*Descriptors:* fish culture, biological stress, aquaculture techniques, fish physiology, anaesthetics, haematology, anaesthesia, *Acanthopagrus schlegeli*


Hseu Jinn-Rong, Yeh Shinn-Lih, Chu Yeong-Torng, Ting Yun-Yuan (1994) **The use of 2-phenoxyethanol as an anesthetic in the transport of black porgy Acanthopagrus schlegeli.** *Journal of Taiwan Fisheries Research.* 3(1):11-18
NAL Call No. SH1 S48
A study was conducted to investigate the application of 2-phenoxyethanol (2-PE) in a closed transport system involving black porgy (*Acanthopagrus schlegeli*) in polyethylene bags. After 24 h sealed packaging, addition of 50-200 ppm 2-PE reduced the accumulation of total ammonia-nitrogen of sea water in the bags containing fish. However, 2-PE could not prevent acidification of the sea water in the bags. In another experiment, effects of 2-PE on the changes of hematological parameters in black porgy were examined at 0, 12, and 24 h after sealed packaging. The results indicated that packaging time and anesthetic did not affect the values of hematocrit, hemoglobin and osmolarity. The value of serum glucose was the only changed parameter during this experiment. The values of serum glucose increased following the duration of packaging time. The 2-PE added group had lower average values of serum glucose than the control group, but the differences between two groups were not significant. Considering the effect of 2-PE on the reduction of the accumulation of total ammonia-nitrogen in sea water and serum glucose of fish during sealed packaging as well as its cheap price, 2-PE was recommended for application in transport of fish.
*Descriptors:* live storage, transportation, anaesthetics, haematology, fish culture, *Acanthopagrus schlegeli*


Hseu Jinn-Rong, Yeh Shinn-Lih, Chu Yeong-Torng, Ting Yun-Yuang (1994) **The**

**anesthetic effect of 2-phenoxyethanol in goldlined sea bream (*Sparus sarba*).** *Journal of Taiwan Fisheries Research.* 2(2):41-49
NAL Call No. SH1 S48
Responses of goldlined sea bream (*Sparus sarba*) to the anesthetic 2-phenoxyethanol (2-PE) were investigated. The induction time (INT) and recovery time (RET) increased when anesthesia reached the later stages. INT increased also with lower concentration of 2-PE, while RET showed the opposite. However, larger fish took longer INT, but RET did not show the other way. Different intervals between two anesthesias resulted different INT (INT2) of the second anesthesia in comparison with that of the first INT (INTI). At 0 or 5 minutes intervals, INT2 was shorter than INT1. As opposite to the above findings, INT2 was longer than INTI at 30 minutes, 1 hour or 6 hours of interval. At 24 hours of interval, half of the anesthetized fish had longer INT2 and the rest of fish had shorter INT2. The results indicated that the anesthetic sensitivity of goldlined sea bream responding to 2-PE would revert after 24 hour's recovery from first anesthesia.
*Descriptors:* anaesthetics, anaesthesia, *Sparus sarba*, evaluation


Hseu Jinn-Rong, Yeh Shinn-Lih, Chu Yeong-Torng, Ting Yun-Yuen (1994) **The changes of hematological parameters during sustained anaesthesia with 2-phenoxyethanol in yellowfin porgy (*Acanthopagrus latus*).** *Journal of Taiwan Fisheries Research.* 2(2):63-68
NAL Call No. SH1 S48
Yellowfin porgy (*Acanthopagrus latus*) was anaesthetized with 2-phenoxyethanol, and sampled at 0, 1, 6, 12, 24 h during anesthesia and 24 h after recovery. Sampling time and anesthetic were found to affect the values of hematological parameters. Most of the time, the control group had higher average values of hematocrit and hemoglobin than the anesthesia group, but the difference between two groups was not significant except in hematocrit values at 24 h during anesthesia. Both sets of values of two groups reached the least level at 12 h, and gradually recovered to starting point. As to serum glucose, the anesthesia group had higher average values than the control group from 1 to 12 h during anesthesia, however, the difference between two groups was significant only at 6 h. The values of serum glucose in the anesthesia as well as the control group decreased from starting point, and never recovered even after 24 h recovering.
*Descriptors:* anaesthesia, anaesthetics, haematology, fish physiology, *Acanthopagrus latus*


Huish MT (1972) **Some responses of the brown bullhead to MS-222.** *Progressive Fish Culturist.* 34(1):27-32
NAL Call No. 157.5 P94
The effect of the anaesthetic MS-222 on the brown bullhead, *Ictalurus nebulosus*, at different temp and conc of anaesthetic, was investigated. Deep stages of anaesthesia were produced at 100

ppm in a relatively short time. The rate of induction of anaesthesia was not clearly related to size of fish. Mortalities were increased and recovery rates slowed at 22° and 27°C, as compared to 7° C, 12°C and 17°C, when treated for 1 hr with 75 and 100 ppm. Fish exposed for 1 hr to 100 ppm at 27°C for < 12 min survived. Those exposed for > 12 min died.

*Descriptors:* MS-222, brown bullhead, *Ictalurus nebulosus*, anesthesia, dosage

Imamura-Kojima H, Takashima F, Yoshida T (1987) **Absorption, distribution and excretion of 2-phenoxyethanol in rainbow trout.** *Bulletin of the Japanese Society for Scientific Fisheries.* 53(8):1339-1342
NAL Call No. 414.9 J274
The absorption, distribution and excretion of 2-phenoxyethanol, which is a piscine anesthetic, were examined in rainbow trout (*Salmo gairdneri*). In fish tranquilized with a sate concentration of 2-phenoxyethanol, it was distributed in the brain, liver, kidney, and gall bladder, especially, the cerebellum. The 2-phenoxyethanol was rapidly excreted and the biological half-life under these experimental conditions was approximately 30 min.
*Descriptors:* bioaccumulation, anesthetics, excretion, *Salmo gairdneri*, phenoxyethanol


Itazawa Y, Takeda T (1982) **Respiration of carp under anesthesia induced by mixed bubbling of carbon dioxide and oxygen.** *Bulletin of the Japanese Society for Scientific Fisheries.* 48(4):489-493
NAL Call No. 414.9 J274
Anesthetization of fish by mixed bubbling into the ambient water of carbon dioxide and oxygen is being tried as a method of live transport. Respiratory parameters were measured with carp (*Cyprinus carpio*) before, during and after anesthesia induced by 1:1 mixed bubbling of carbon dioxide and oxygen. During the anesthesia, oxygen content and oxygen saturation of the arterial blood was maintained at levels higher than or equal to the pre-anesthetic ones owing to very high $pO_2$ accompanied with elevated Ht and Hb in the blood, in spite of enormously high $pO_2$ which ought to reduce the oxygen affinity of the blood. Gill ventilation was also maintained at the pre-anesthetic level due to increased frequency of respiration, notwithstanding its reduced stroke volume. Oxygen consumption was reduced to one-half its pre-anesthetic level, accompanied with a sharp drop of oxygen utilization at the gills.
*Descriptors:* anesthesia, transportation, respiration, live storage, *Cyprinus carpio*


Iwama GK, Mcgeer JC, Pawluk MP (1989) **The effects of five fish anaesthetics on acid - base balance, hematocrit, blood gases, cortisol, and adrenaline in rainbow trout.** *Canadian Journal of Zoology / Journal Canadien de Zoologie.* 67(8):2065-2073

NAL Call No. 470 C16D

Some physiological aspects of five fish anaesthetics in rainbow trout (*Oncorhynchus mykiss*) were investigated. The effects of benzocaine, 2-phenoxyethanol, MS-222 (Sandoz), metomidate, and carbon dioxide gas ($CO_2$) on acid - base regulation, hematocrit, blood gases, and cortisol and adrenaline concentrations were determined in resting rainbow trout fitted with chronic catheters in the dorsal aorta. A severe hypoxia developed with the cessation of breathing in deep anaesthesia. This was accompanied by a rise in blood $pCO_2$ and adrenaline concentration, and a fall in blood pH. Blood bicarbonate concentrations remained unchanged and cortisol concentrations declined with time. There was a transient increase in hematocrit coinciding with the increase in adrenaline concentrations.

*Descriptors:* anesthetics, fish physiology, hematology, steroids, hypoxia, *Oncorhynchus mykiss*



Iwama GK, Yesaki TY, Ahlborn D (1991) **The refinement of the administration of carbon dioxide gas as a fish anesthetic: The effects of varying the water hardness and ionic content in carbon dioxide anesthesia.** *ICES (International Council for the Exploration of the Sea) Council Meeting Papers., ICES, Copenhagen (Denmark).* 29 pp

The results indicate that two of three treatments that involved the addition of $NaHCO_3$ were capable of reducing the amount of stress experienced by juvenile steelhead (*Oncorhynchus mykiss*) when anesthetized by $CO_2$. Treatment 3, $NaHCO_3$ only, had significantly lower cortisol, lactate, and Hct values versus the control treatment. Consequently, it was concluded that the fish in treatment 3 exhibited the lowest overall stress responses to $CO_2$ anesthesia. The fish in treatment 9, $NaHCO_3$ and NaCl, had significantly lower cortisol and Hct values and was determined to be the next most effective treatment in reducing the stress associated with $CO_2$ anesthesia. Treatments 3, 6, and 9 had water pH levels that were comparable to that of the water in which the fish were originally held. “Hyperactivity” was observed to be somewhat reduced when $NaHCO_3$ was added to the anesthetic bath water.

*Descriptors:* anaesthesia, carbon dioxide, biological stress, *Oncorhynchus mykiss*



Jeney Z, Jeney G, Olah J, Siwicki A, Danko I (1986) **Propanidid, a new anaesthetic for use in fish propagation.** *Aquaculture.* 54(1-2):149-156

NAL Call No. SH1A6

Propanidid, 3-methoxy-4-(N,N-diethyl-carbamoyl-methoxy)-phenylacetic acid n-propyl ester, was applied during artificial propagation of common carp, *Cyprinus carpio* L., and compared with MS 222. Primary and secondary stress effects from Propanidid and MS 222 were characterized by measuring the plasma adrenaline and noradrenaline levels, haemoglobin, blood glucose, plasma $Ca^{++}$ and $Cl^-$ concentrations, haematocrit and leucocrit values and activity of transaminases (GOT, GPT) in plasma. General effects of handling stress during propagation were reflected by significant hyperglycemia, decreasing $Ca^{++}$ and $Cl^-$ concentrations, and a significant increase in

transaminase activity in plasma. Both anaesthetics decreased handling stress, though MS 222 caused a greater increase of catecholamines and of GPT and decrease of leucocrit and plasma $Ca^{+}$ $^{+}$. Results of artificial propagation were similar in the two experimental groups.
*Descriptors:* anesthetics, fish culture, biological stress, fish handling, transportation, *Cyprinus carpio*


Jennings CA, Looney GL (1998) **Evaluation of two types of anesthesia for performing surgery on striped bass.** *North American Journal of Fisheries Management.* 18(1):187-190
NAL Call No. SH219.N66
Tricaine (MS-222) is the most widely used anesthetic for fishes, but induction and recovery times are rather long. Studies on salmonids have shown that electroanesthesia is a good alternative to MS-222 for short term (<1 min) immobilization. However, data on longer-duration (3-5-min) immobilization needed for surgical procedures are lacking. We analyzed induction and recovery times for 20 adult (52-81-cm) striped bass *Morone saxatilis* immobilized with electroanesthesia and MS-222. We defined induction time as the interval from the onset of each treatment until the fish was immobilized (i.e., did not respond to tactile stimuli) and recovery time as the interval from the fish's return to the water to its resumption of normal swimming. Surgical procedures similar to those necessary to implant a radio transmitter were performed on each fish. Induction time for fish immobilized with electroanesthesia (geometric mean, 8 s; 95% confidence interval [CI], 3-21 s) was much shorter than that for fish immobilized with MS-222 (geometric mean, 47 s; 95% CI, 38-58 s) (P = 0.0006). Additionally, fish immobilized with electroanesthesia recovered much faster (geometric mean, 9 s; 95% CI, 4-19 s) than fish immobilized with MS-222 (geometric mean, 206 s; 95% CI, 156-272 s) (P less than or equal to 0.0001). Faster induction and recovery times of fish immobilized with electroanesthesia and the ability to process more fish per unit time are major benefits of this technique.
*Descriptors:* anaesthesia, fishery biology, tagging, fishery management, *Morone saxatilis*, surgery, rockfish, mortality, striped bass


Josa Serrano A, Espinosa Velazouez E, Esteban Alonso J, del Nino Jesus A, Osanz Castan E (1993) **Use of anaesthetic 2-phenoxyethanol in carps (*Cyprinus carpio*): Levels blood concentration.** *Actas del IV Congreso Nacional de Acuicultura, Centro de Investigaciones Marinas, Pontevedra (Spain).* pp. 731-736
In this work we studied the 2-Phenoxy ethanol concentration levels in the blood of Carp (*Cyprinus carpio*) after its use as anesthesic at different time, concentrations, temperatures and exposition. Anaesthesia levels as well as induction and recovery times are defined.
*Descriptors:* fish culture, anaesthesia, serological studies, blood, temperature, *Cyprinus*

*carpio*, 2-phenoxiethanol


Kahl MD, Jensen KM, Korte JJ, Ankley GT (2001) **Effects of handling on endocrinology and reproductive performance of the fathead minnow.** *Journal of Fish Biology.* 59 (3):515-523
NAL Call No. QL614 J68
Anaesthesia with MS-222 followed by intra-peritoneal (ip) injection (with a 10% ethanol in corn oil carrier) of fathead minnow either as one or three (weekly) treatments did not affect survival, behaviour or secondary sexual characteristics of the fish. Fecundity of the fish, as indicated by fertility and hatching success, was also unaffected. Gonadal condition (relative gonad mass, histopathology) was not altered in either sex. Male and female plasma sex steroids (beta - oestradiol, testosterone, 11-ketotestosterone) and male vitellogenin concentrations were not significantly affected by the treatments. Females subjected to either ip treatment regime had significantly higher plasma vitellogenin concentrations than control females. However, based on previous data, this difference did not appear to be treatment-related. Overall, exposure of fathead minnows to chemicals via the ip route should not confound the interpretation of toxicity tests with potential endocrine disrupting chemicals.
*Descriptors:* reproductive behavior, methodology, fish handling, anaesthetics, survival, bait culture, behaviour, secondary sexual characters, fecundity, fish physiology, animal behavior, sexual reproduction, toxicity, *Pimephales promelas*, fathead minnow, fathead minnows


Kaiser H, Vine N (1998) **The effect of 2-phenoxyethanol and transport packing density on the post-transport survival rate and metabolic activity in the goldfish, *Carassius auratus*.** *Aquarium Sciences and Conservation*. 2(1):1-7
ISSN: 1357-5325
To test the hypothesis that the anaesthetic 2-phenoxyethanol would reduce the metabolic rate and allow for higher transport packing densities, goldfish (3.93 plus or minus 1.99 g) were transported for 48 h at 25, 50 and 75 fish per 500 ml combined with anaesthetic concentrations of 0, 0.25 and 0.35 ml/l. The anaesthetic did not affect the survival rate or the oxygen and ammonia concentrations. Thus, its use could not be recommended for the transport of goldfish. It is suggested that optimum packing densities be based on a minimum post-transport oxygen value of 4 mg/l for goldfish.
*Descriptors:* fish physiology, respiration, oxygen consumption, dissolved oxygen, live storage, transportation, ornamental fish, aquarium culture, freshwater fish, anaesthetics, *Carassius auratus*


Kaminski R, Myszkowski L, Wolnicki J (2001) **Response to 2-phenoxyethanol in juvenile *Vimba vimba* (L.).** *Archiwum Rybactwa Polskiego/Archives of Polish Fisheries. Olsztyn* 9(1):71-78

NAL Call No. SH293 P7A73
In Poland, the anaesthetic effect of 2-phenoxyethanol on juvenile *Vimba vimba* (L.) aged 38-179 days post-hatch (26-56 mm total length) was studied at 25°C. The concentration which anaesthetized 100% of the fish within 10 min without causing mortality after 15 min of exposure ranged from 0.35 to 0.48 g/dm super(3) in 38 day-old vimba and from 0.33 to 0.43 g/dm super(3) in older fish. The induction and recovery times were shorter in the initial phase of vimba juvenile life than in older fish. In fish of the same age, induction time or recovery time did not depend on their size or condition (Fulton's coefficient). At 25°C, 2-phenoxyethanol at 0.40 g/dm super(3) may be used to efficiently and safely anaesthetize vimba juveniles.
*Descriptors:* alcohols, fry, juveniles, *Vimba vimba*, anaesthesia, anaesthetics, phenols, freshwater fish, freshwater aquaculture


Kaneko K (1982) **On the removal of larger freshwater fishes.** *Biennial Report of the Keikyu Aburatsubo Marine Park Aquarium. Miura.* 1981(11):39-45
Because of reconstruction of the tank where Arapaima and other freshwater fishes had been kept, it was necessary to temporarily remove them to another tank. Arapaima and Lepisosteus have the gas bladder well developed for aerial respiration. Some anesthetic tests were examined with such physostomous fish as Protopterus and Channa prior to the removal. In practical uses, 10% - Quinaldine was added to the water in concentration of 100 ppm. The 2 anesthesized Osteoglossum was removed at first by handling with a blanket, and the 3 species of catfish were succeeded in the same manner. The concentration amounted to 150 ppm. The 3 Mylopharyngodon was removed. Arapaima and Lepisosteus still kept their air-breathing, so 200 ppm-MS-222 and 20%-Fluothane were sprayed at their gills as a supplementaly anesthetic treatment.
*Descriptors:* aquaria, fish handling, anesthesia, freshwater fish


Kazun K, Siwicki AK (2001) **Propiscin -- a safe new anaesthetic for fish.** *Archiwum Rybactwa Polskiego/Archives of Polish Fisheries. Olsztyn.* 9(2):183-190
NAL Call No. SH293 P7A73
Anaesthetics are needed when handling fish, especially during tagging. However, most anaesthetics applied at present have a strong toxic effect on fish. For this reason it is only permissible to keep fish anaesthetized for a short time. A new anaesthetic, Propiscin, which allows fish to be anaesthetized for up to 0.5 h, has been successfully tested in Poland. It contains a 0.2% stabilized solution of etomidate and can be used as a bath. When administered correctly, the required disappearance of sense perception and motor reflexes in the fish can be obtained in about 2-4 min. The low toxicity of this pharmacological confection has been proved according to a full set of clinical, toxicological, hematological

and biochemical criteria. Clinical tests have been conducted on with many fish species, mainly salmonids.
*Descriptors:* anaesthetics, anaesthesia, freshwater aquaculture, pharmacology, drugs, fish culture, fish handling, toxicology, Propiscin


Keene JL, Noakes DLG, Moccia RD, Soto CG (1998) **The efficacy of clove oil as an anaesthetic for rainbow trout, *Oncorhynchus mykiss* (Walbaum).** *Aquaculture Research.* 29(2):89-101
NAL Call No. SH1 F8
The anaesthetic effects of clove-oil-derived eugenol were studied in juvenile rainbow trout, *Oncorhynchus mykiss* (Walbaum). Acute lethality and the effects of multiple exposures to eugenol were measured. The estimated 8-96 h LC sub(50) for eugenol was found to be approximately 9 p.p.m. Times to induction and recovery from anaesthesia were measured and compared with MS-222 under similar conditions. Eugenol generally induced anaesthesia faster and at lower concentrations than MS-222. The recovery times for fish exposed to eugenol were six to 10 times longer than in those exposed to similar concentrations of MS-222. Clove oil eugenol was determined to be an acceptable anaesthetic with potential for use in aquaculture and aquatic research. Doses of 40-60 p.p. m. eugenol were found to induce rapid anaesthesia with a relatively short time for recovery in juvenile trout.
*Descriptors:* fish culture, anaesthetics, lethal effects, recovery, *Oncorhynchus mykiss*, eugenol, fish culture, anaethestics


Klaverkamp JF, Lockhart WL, Metner WL, Grift N (1976) **Effects of chronic DDT/DDE exposure on anesthetic induction and recovery times in rainbow trout (*Salmo gairdneri*).** *Journal of the Fisheries Research Board of Canada.* 33(6):1331-1334
NAL Call No: 442.9 C16J
In rainbow trout (*S. gairdneri*) fed pellets containing 4.55{mu}g/g of p, p'-DDT and 6.81{mu}g/g of p, p'-DDE every other day. Anesthetic induction and recovery times of phenoxyethanol (PE) were less than those in trout fed control pellets. No interactions were observed in fish fed DDT/ DDE and anesthetized with ethyl m-aminobenzoate methane sulphonate (M.S. 222). Differences observed between fish fed DDT/DDE and anesthetized with PE as compared to M.S. 222 could be due either to enhanced metabolism of PE or to the fact that PE and M.S. 222 have different modes or sites of action.
*Descriptors:* insecticides, DDT, anaesthetics, *Oncorhynchus mykiss*


Knoph MB (1995) **Effects of metomidate anaesthesia or transfer to pure sea water on plasma parameters in ammonia-exposed Atlantic salmon (*Salmo salar* L.) in sea**

**water.** *Fish Physiology and Biochemistry.* 14(2):103-109
ISSN: 0920-1742
Atlantic salmon (*Salmo salar* L) postsmolts weighing 150 plus or minus 53 g were exposed to 14-15 mg/l TA-N (total ammonia-N) in sea water in 1 m super(3) tanks for 24h. Blood samples were then taken A) immediately after the fish were netted from the exposure tanks and stunned by a blow to the head; B) 2-20 min after the fish were transferred to 15 l of an anaesthetic solution of metomidate in “ammonia-free” sea water; or C) 2-20 min after the fish were transferred to 15 l of "ammonia-free" sea water. Plasma TA-N level was 18% lower in the anaesthetised fish compared to in the fish sampled directly from the exposure tanks (p less than or equal to 0.05), and accordingly 16% lower in the fish transferred to pure sea water although this difference was not significant (p = 0.07). Plasma glucose level was higher in the fish transferred to pure sea water than in the fish receiving the two other treatments (p less than or equal to 0.05), but plasma urea, osmolality, $Na^{+}$, $Cl^{-}$, $Ca^{++}$ or $Mg^{++}$ levels did not vary significantly between the difference treatments. Plasma TA-N level increased with time in the fish in the metomidate solution (p less than or equal to 0.02).
*Descriptors:* fish physiology, anesthesia, *Salmo salar*, blood, ammonia, hematology, biological sampling, metomidate


Kohbara J, Nanba K, Murachi S (1987) **The heart rate of carp anesthetized with tetraethylene glycol dibutyl ether.** *Bulletin of the Japanese Society of Scientific Fisheries.* 53(4):681
NAL Call No. 414.9 J274
An anesthetic effect on a carp (*Cyprinus carpio*) produced by tetraethylene glycol dibutyl ether was discovered. To clarify the physiological condition of carp under the anesthetic effect produced by this agent, the heart rate was measured during the anesthetic period and compared with the anesthetic effect produced by MS-222. Both MS-222 and tetraethylene glycol dibutyl ether produced an increase in the heart rate at first. The heart rate of the carp anesthetized with MS-222 maintained a high beat rate during the experiment. That affected by tetraethylene glycol dibutyl ether, however, fell off to below the heart rate of the fish in normal condition. It is estimated that the anesthetic mechanism of this agent is very different from that of MS-222.
*Descriptors:* heart, anesthesia, *Cyprinus carpio*, heart rate, tetraethylene glycol dibutyl ether


Korstrom JS, Birtwell IK, Piercey GE, Spohn S, Langton CM, Kruzynski GM (1996) **Effect of hypoxia, fresh water, anaesthesia and sampling technique on the hematocrit values of adult sockeye salmon (*Oncorhynchus nerka*).** *Canadian technical report of fisheries and aquatic sciences/Rapport technique canadien des sciences halieutiques et aquatiques. Imprint varies.* 34 pp ISSN: 0706-6457

The hematocrit values of adult sockeye salmon, *Oncorhynchus nerka*, were determined after the fish were subjected to sublethal hypoxia in salt water under simulated estuarine conditions, a residual oxygen bioassay, transfer from sea water to fresh water, and a lethal dose of the anaesthestic MS-222. Irrespective of treatment, hematocrit values determined in sequentially-collected aliquots of blood decreased in relation to the elapsed sampling time. A systematic and significant error occurred due to the ordinal number of sampling the hematocrit capillary tubes a maximum of three tubes of blood should be collected per fish for hematocrit determination. Hematocrit values of fish anaesthetized with 200 mg/L MS-222 were not significantly higher than those from control fish. Adult male and female sockeye salmon had similar hematocrit values. Hematocrit values were significantly increased after exposure to longer (48h) but not to shorter (6hr) term hypoxia. Hematocrit values were significantly elevated after 8.5 weeks, but not after 2.5 weeks residence in fresh water following transfer from sea water. The highest hematocrit values were from fish exposed to the residual oxygen bioassay which subjected the salmon to the greatest hypoxic stress. The utility of hematocrit values in relation to environmental stressors is discussed.
*Descriptors:* hypoxia, fresh water, anaesthesia, adults, haemoglobins, blood cells, oxygenation, bioassays, fish physiology, *Oncorhynchus nerka*


Kreiberg H (1992) **Metomidate sedation minimizes handling stress in chinook salmon.** *Proceedings, 1992 Meeting of the Aquaculture Association Of Canada, 1-3 June, 1992, University of British Columbia, Vancouver, BC. Bulletin of the Aquaculture Association of Canada. St. Andrews NB.* 92(3):52-54
NAL Call No. SH37.B8
Use of a recently introduced fish anaesthetic, metomidate, for controlling physiological response to stress from handling procedures in chinook salmon Oncorhynchus tshawytscha is described. Fish given a pre-handling exposure to metomidate responded to a crowding and netting procedure with relatively little elevation of plasma cortisol compared to other fish handled without metomidate. Plasma cortisol in the metomidate-treated fish rose from resting level of 28.4 plus or minus 1.8 ng/mL to 61.0 plus or minus 7.5 ng/mL, compared to 204.9 plus or minus 16.2 ng/mL in untreated fish (mean plus or minus 2SE).
*Descriptors:* fish culture, fish handling, biological stress, therapy, drugs, *Oncorhynchus tshawytscha*, metomidate


Kreiberg H, Powell J (1991) **Metomidate sedation reduces handling stress in chinook salmon.** *World Aquaculture.* 22(4):58-59 ISSN: 1041-5602
NAL Call No. SH1.W62
Exposure to the recently introduced fish anaesthetic, metomidate, in the fishes' home culture container prior to a handling stress resulted in considerably reduced plasma corticosteroid response over untreated stressed fish. A practical and inexpensive procedure in use since 1989 is described for tanks, raceways and netpens. The unique sedative properties of metomidate are

considered to have broad potential benefit to posthandling health and survival in sensitive fish such as chinook salmon. A requirement to handle live fish in order to carry out procedures such as transportation, grading, or benign or minor invasive sampling is recognized by many fish culturists as a potentially stressful experience which may result in reduced vigor or mortality in the affected stock. A number of researchers have described aspects of the physiological consequences of handling procedures used with temperate and coolwater fishes such as Pacific salmon species, various trout, striped bass and red drum. Essentially, the fright-flight response is triggered, involving adrenaline and subsequent impacts on the fish's ability to maintain its blood constituents, osmoregulation and immune system preparedness. Most reports have singled out the netting and capture phase of various procedures as the major contributor to overall stress associated with a particular procedure. Reports of the suitability of a recently introduced fish anaesthetic, metomidate, for minimizing the stress response to handling in striped bass and Atlantic cod suggested applications in the culture of Pacific salmon, particularly chinook salmon. Over a number of practical trials with different sizes of chinook and coho salmon, we developed a standard procedure for light sedation of fish before a handling disturbance. This report provides a summary and evaluation of our pre-handling technique. (DBO)
*Descriptors:* marine aquaculture, aquaculture techniques, fish physiology, *Oncorhynchus tshawytscha*


Kumlu M, Yanar M (1999) **Effects of the anesthetic quinaldine sulphate and muscle relaxant diazepam on sea bream juveniles (*Sparus aurata*).** *Israeli Journal of Aquaculture/Bamidgeh.* 51(4):143-147
NAL Call No. SH117 I75B36
In this investigation, the effects of an anesthetic, quinaldine sulphate (QS), and a muscle relaxant, diazepam (D), on sea bream juveniles (*Sparus aurata*) were studied. The application of diazepam significantly increased the safety level of the anesthetic QS for the sea bream juveniles. The fish entered light anesthesia at 5 ppm QS + 1 ppm D, as compared to 10 ppm QS. Similarly, the deep anesthesia level was reached at only 7.5 ppm QS + 1 ppm D as compared to 15 ppm QS. The use of QS alone at high concentrations (15-20 ppm) resulted in mortality of 30% to 100%. No mortality occurred in the fish treated with QS plus D at all anesthesia levels. Depending on the anesthetic concentrations used, the time to loss of balance and the recovery time were 0-2 min and 2-6 min, respectively. Administration of diazepam with a lower concentration of QS significantly enhanced the anesthesia, eliminated the undesirable effects of QS and reduced the excitement and hyperactivity of the fish in the confined space, without leading to mortality. Suitable light and deep sedation stages of anesthesia for transportation and handling of sea bream juveniles (6-7 g) were obtained with dosages of 5 ppm QS + 1 ppm D and 7.5 ppm QS + 1 ppm D, respectively.
*Descriptors:* anaesthetics, fish culture, aquaculture techniques, fish larvae, survival, diazepam, anesthetics, quinaldine sulfate, *Sparus aurata,* quinaldine sulphate, diazepam, gilthead seabream


Ladu BMB, Ross LG (1997) **The effect of methods of immobilization on the**

**haematology and tissue chemistry of rainbow trout *Oncorhynchus mykiss* Walbaum.** *Journal of Aquatic Sciences.* 12:31-41 ISSN: 0189-8779
The influence of methods of immobilization on the haematology and tissue chemistry of rainbow trout *Oncorhynchus mykiss* was investigated. Both chemical and electroanaesthesia had similar effects on haematology and tissue chemistry of the fish. Generally, however, haemoconcentration was minimized by electroanaesthesia and it is recommended as the preferred method of sampling because it is cheap, safe and less stressful. The demands on respiration, nutrient metabolism, ionoregulation and osmoregulatory activities were variously effected by each stressor.
*Descriptors:* haematology, fish physiology, tissues, histochemistry, anaesthesia, biological stress, *Oncorhynchus mykiss*


Laidley CW, Leatherland JF (1988) **Cohort sampling, anaesthesia and stocking-density effects on plasma cortisol, thyroid hormone, metabolite and ion levels in rainbow trout, *Salmo gairdneri* Richardson.** *Journal of Fish Biology.* 33(1):73-88
NAL Call No. QL614 J68
The effect of serial removal of fish from aquaria, anaesthesia and stocking density on plasma cortisol, thyroid hormone, metabolite and ion levels was examined in rainbow trout, Salmo gairdneri, to determine the consequences of normal handling and maintenance procedures on the activity of the pituitary-adrenal and pituitary-thyroid axes in the species.
*Descriptors: Salmo gairdneri, Oncorhynchus mykiss*, anaesthesia, fish handling, biological stress, fish physiology, stocking density


Laitinen M, Nieminen M, Pasanen P, Hietanen E (1981) **Tricaine (MS-222) induced modification on the metabolism of foreign compounds in the liver and duodenal mucosa of the splake (*Salvelinus fontinalis* X *Salvelinus namaycush*).** *Acta Pharmacologica et Toxicoogica.* 49(2):92-97
The splake, a popular game fish, is a crossbreed which must be reared in nurseries. The fish are marked under anaesthesia for later study. We anlayzed the effect of a common anaesthetic, tricaine (MS-222), on the metabolism of foreign compounds in the liver and duodenum of the splake. In the liver and to some extent in the duodenum, aryl hydrocarbon hydroxylase and epoxide hydrase activities were reduced during treatments. The ethoxycoumarin O-deethylase activities were not affected in either the liver or duodenum. Tricaine significantly decreased the hepatic UDP-glucuronosyltransferase activity. The decrease was greater when the aglycone used was p-nitrophenol than with methylumbelliferone. A similar effect was also found after trypsin treatment of the microsomes. No significant decrease in the UDP-glucuronosyltransferase activity was detected in the duodenal mucosa. This was the case when both p-nitrophenol and methylumbelliferone were used as aglycones.
*Descriptors:* anaesthetics, enzymatic activity, liver, intestines, *Salvelinus fontinalis*,

*Salvelinus namaycush*, MS-222


Lambooij E, Vis JW, van de Kloosterboer RJ, Pieterse C (2002) **Welfare aspects of live chilling and freezing of farmed eel (*Anguilla anguilla*): neurological and behavioural assessment.** *Aquaculture*. 210 (1/4):159-169
NAL Call No. SH1 A6
The overall objective of the study was to evaluate a slaughter method of eels, which consisted of chilling until their body temperature was <5oC for stunning, and subsequently placing them in cold brine at -18oC for 15 min for killing. Three distinct experiments and a control were performed. First, 19 eels with an average live weight of 758 " 44 g were restrained and equipped with EEG, ECG electrodes and a temperature sensor inside the body. Then, they were placed in the ice water. Indices for the induction of unconsciousness and insensibility were the appearance of theta and delta waves and no response on pain stimuli, which disappeared at a body temperature of 8.0 " 2.1oC after 12 " 5 min in 15 eels. The responses to pain stimuli did not disappear in three eels. Within a confidence level of 95%, the percentage of eels that was not effectively stunned during the procedure in ice water of <5 oC was at least 5%. The heart rate decreased from 24 " 10 beats/min (n=14) to 7 " 4 (n=11) and became irregular during cooling down. When placed in the brine water of -18ºC, the EEG showed rapid and extreme depolarization of the membranes, which started after 27 "17 seconds (n=18). The ECG showed fluttering of the heart in all eels. None of the eels recovered after this procedure. For 10 eels with an average live weight of 128 " 27 g, it was observed that the body temperature decreased from 17.1 " 0.6 to 4.0 " 0.5ºC in the ice water. After 15 min in the brine water of -16.1 " 2.2ºC, the body temperature decreased to -3.1 " 2.3ºC. Finally, three groups of 7 eels and 8 single eels were placed in ice water of -0.0 " 0.1ºC. The observation of unrestrained eels revealed four phases. Animals were (1) swimming around in the water, (2) attempting to escape from the ice water, (3) pressing their nose to the wall or corner while showing clonic muscle cramps, and finally (4) breathing only, while all other muscle activity was totally suppressed. Afterwards, they were transferred to cold brine at -18ºC, and none of the eels recovered. The eight control eels, which were transferred to water at 18ºC swam around, except for one that was lying in an S-shape position at the bottom. After 570 and 605 seconds, two eels tried to escape from the box. The obtained results showed that the eels, which were transferred from water at 18ºC to ice water, might be stressed, a specific behaviour and an irregular heart rate were observed. From an animal welfare point of view, it is therefore not recommended to stun eels by live chilling. Moreover, at least 5% of the eels will not be stunned at a body temperature of <5ºC. Placing eels in brine water of -18ºC is an effective method to kill the eels before slaughter. However, it cannot be recommended to place conscious eels in cold brine water, because it takes more than 27 seconds before

unconsciousness may be induced.
*Descriptors:* animal behaviour, animal welfare, body temperature, chilling, freezing, heart rate, neurology, pain, slaughter, stunning, eels, Anguilla, Anguillidae, Anguilliformes, Osteichthyes, fishes, diadromous fishes, aquatic animals, aquatic organisms


Le Bras YM (1982) **Effects of anaesthesia and surgery on levels of adrenaline and noradrenaline in blood plasma of the eel (*Anguilla anguilla* L.).** *Comparative Biochemistry and Physiology, C.* 72C(1):141-144
NAL Call No. QP1 C6
The effects of surgery and anaesthesia on adrenaline and noradrenaline plasma levels were investigated in the eel (*Anguilla anguilla* L.). Effect of surgery: highest values were obtained when putting back the fish in water. Three hours after surgery, adrenaline and noradrenaline plasma levels were always significantly higher than those obtained 24 and 48 hr after surgery. Effect of anaesthesia: anaesthesia only had no effect on adrenaline and noradrenaline plasma levels. It was concluded that the trauma of surgery was mainly responsible for the elevation of CA plasma levels in the eel. A minimum post-operative period of 24 hr should be allowed before any blood sampling for estimation of resting CA plasma levels. Resting adrenaline and noradrenaline plasma levels, 48 hr after surgery, were respectively 1.31 " 0.38 and 3.37 " 0.41 pmol/ml.
*Descriptors:* anaesthesia, biological stress, blood, *Anguilla anguilla*, adrenaline, noradrenaline


Lewis DH, Tarpley RJ, Marks JE, Sis RF (1985) **Drug induced structural changes in olfactory organ of channel catfish *Ictalurus punctatus*, Rafinesque.** *Journal of Fish Biology.* 26(3):355-358
NAL Call No. QL614 J68
The fish anesthetic tricaine methanosulfate destroyed the cilia on olfactory sensory epithelia of channel catfish (*I. punctatus*) when fish were exposed to tranquilizing doses of the drug. Cilia on the nonsensory epithelium appeared to be unaffected by multiple exposures of the drug. Sensory cilia regenerated within 28 days after exposure.
*Descriptors:* anesthetics, histopathology, olfactory organs, *Ictalurus punctatus*


Limsuwan C, Grizzle JM, Plumb JA (1983) **Etomidate as an anesthetic for fish: Its toxicity and efficacy.** *Transactions of the American Fisheries Society.* 112(4):544-550
NAL Call No. 414.9 AM3
Etomidate was tested as an anesthetic on channel catfish Ictalurus punctatus, golden shiners Notemigonus crysoleucas, and bluegills Lepomis macrochirus. The 24-hour median lethal

concentration (LC50) at various temperatures was lowest for bluegills (0.61-0.68 mg/liter) and highest for golden shiners (1.87-2.73 mg/liter). Generally, etomidate was more toxic, and induction of anesthesia and recovery from anesthesia were slower, at 17ºC than at 22 ºC and 27 ºC. Both channel catfish and golden shiners were anesthetized within 15 minutes by 3 mg/liter, and all of the fish survived at this concentration for 30 minutes. concentrations of 0.2 and 0.4 mg/liter sedated channel catfish, and 0.4 and 0.6 mg/liter sedated golden shiners. The safety index LC50/EC50 (median effective concentration) for anesthesia of channel catfish and golden shiners at 22ºC " 1ºC decreased from 6.2 to 5.0 and 7.6 to 4.0, respectively, as exposure length increased from 10 to 80 minutes.
*Descriptors:* anesthetics, toxicity, *Ictalurus punctatus, Notemigonus crysoleucas, Lepomis macrochirus*, utilization, evaluation, etomidate


Limsuwan C, Limsuwan T, Grizzle JM, Plumb JA (1983) **Stress response and blood characteristics of channel catfish (*Ictalurus punctatus*) after anesthesia with etomidate.** *Canadian Journal of Fisheries and Aquatic Sciences.* 40(12):2105-2112
NAL Call No: 442.9 C16J
Continuous anesthesia of channel catfish (*Ictalurus punctatus*) with 0.6 mg/L etomidate for 96 h caused a small but statistically significant decrease in plasma protein concentration at all sampling periods. Anesthetized fish were not stressed by the periodic sampling. Fish anesthetized with 3 mg/L etomidate and then confined in a net for 10 min had reduced plasma cortisol response and no significant plasma glucose increase compared with unanesthetized controls. Anesthesia did not prevent hyperchloremia that developed 3 h after the 10-min confinement. No histological changes were found in fish anesthetized with etomidate. Anesthesia with etomidate before netting could be useful when handling fish because of the reduced stress response.
*Descriptors:* anaesthesia, fish culture, haematology, histology, biological stress, *Ictalurus punctatus*


MacAvoy SE, Zaepfel RC. ( 1997) **Effects of tricaine methanesulfonate (MS-222) on hematocrit: First field measurements on blacknose dace.** *Transactions of the American Fisheries Society.* 126(3):500-503
NAL Call No. 414.9 AM3
Tricaine methanesulfonate (MS-222) is an anesthetic commonly used to reduce fish stress during transport or sampling. The exposure of blacknose dace Rhinichthys atratulus to MS-222 at concentrations of 300 mg/L or 500 mg/L for 9 min or less did not raise hematocrit levels above those of controls. Hematocrit levels tended to be somewhat lower in experimental groups than in controls; however the only significant difference (P = 0.044) among treatments occurred between the control fish (35% " 2.3; N = 6) and fish exposed to

500 mg/L for 3 min (30% "1.8; N = 7). This difference suggests that initial exposure to MS-222 may cause stress or, less likely, that the anesthetic has some inherent hemodilution effect. Workers who monitor environmental acidification may be concerned with the hematocrit of the acid-sensitive blacknose dace because hematocrit increases during acid stress. The use of MS-222 to ease hematocrit sampling should not elevate measurements.
*Descriptors:* anaesthetics, blood, biological stress, therapy, acidification, pollution indicators, anesthetics, hematocrit, stress, USA, Virginia, Blue Ridge, Paine Run, tricaine methanesulfonate, *Rhinichthys atratulus*, USA, Virginia, Blue Ridge Mts., Paine Run, therapy, Blacknose dace


MacKinlay DD, Johnson MVD, Celli DC (1994) **Evaluation of stress of carbon dioxide anaesthesia.** *High Performance Fish: Proceedings of an International Fish Physiology Symposium at the University of British Columbia in Vancouver, Canada, July 16-21 1994. Fish Physiology Association, Vancouver, BC (Canada)*. pp. 421-424
NAL Call No. QL639.1 I58 1994
The Salmonid Enhancement Program (SEP) has applied coded-wire tags to 7-12 million fish per year since the early 1980's, an operation that requires short-term (5-10 min) anaesthesia. Tricaine methane sulphonate (TMS) and 2-phenoxyethanol (TPE) were the chemicals most often used in the early years of the SEP. Several concerns, including the safety of hatchery workers using TPE, warnings about releasing fish into seawater soon after exposure to TMS and increasing restrictions on the availability of drugs for routine procedures has led to a switch to carbon dioxide gas as the preferred anaesthetic at SEP hatcheries. One of the marked differences between anaesthesia with carbon dioxide and other anaesthetics is that fish exhibit an extreme hyperactive response when first immersed in water containing a high concentration of carbon dioxide. This led to concerns that the fish were extraordinarily stressed by carbon dioxide anaesthesia, which led to this series of experiments to determine if the carbon dioxide caused a greater degree of measurable physiological stress than the other anaesthetics. Cortisol was chosen as the index of stress, in accordance with common practice (Donaldson, 1981).
*Descriptors:* biological stress, tagging, anaesthesia, carbon dioxide, fish physiology, fish handling, Salmonidae, fish culture


Malmstroem T, Salte R, Gjoeen HM, Linseth A (1993) **A practical evaluation of metomidate and MS-222 as anaesthetics for Atlantic halibut (*Hippoglossus hippoglossus* L.).** *Aquaculture.* 113 (4):331-338
NAL Call No. SH1A6
Metomidate and MS-222 were tested as anaesthetics for Atlantic halibut (*Hippoglossus hippoglossus* L.) at temperatures of 9.5 "0.3°C and 10.5 " 0.3°C. An effective concentration of the drug was defined as one giving a sure state of anaesthesia for 75% of the fish after an exposure time of less than 5 min. The lowest effective concentration of metomidate was 10

mg/l; with MS-222, concentrations of 250 mg/l were required. Doses should further be kept below 60 mg metomidate/l or 480 mg MS-222/l. There was interaction between anaesthetic and dose for both drugs with respect to the required exposure time, which focuses on the necessity of testing several doses when a new anaesthetic is to be used on a given species. In is concluded that metomidate gives a broader safe anaesthetic range with a lower effective dose than MS-222.
*Descriptors:* fish culture, aquaculture techniques, pharmacology, anaesthetics, comparative studies, *Hippoglossus hippoglossus*, metomidate, MS-222


Marx H, Brunner B, Weinzierl W, Hoffmann R, Stolle A (1996) **Comparative investigations on different methods for stunning fish with special regard to meat quality parameters.** *Proceedings of the Conference of IIR Commission C2, Bordeaux Colloquium -- Refrigeration and Aquaculture. Froid et Aquaculture -- Colloque de Bordeaux, Compte-Rendu de la Reunion de la Commission C2 de l' IIF*. pp. 199-206
Taking into account aspects of meat quality and animal welfare, three methods for stunning fish were compared: manually (blow on the head, stab in the neck) with electricity and using $CO_2$. The following results were obtained for eel (n = 72), carp (n = 120) and trout (n = 54). From the view of animal welfare, the effects on the fish were judged. Excitation and mucus secretion, as weIl as the period of lime until the fish were in anaesthesia were recorded. With manual and electrical stunning, aIl fish were anaesthetized almost immediately, while using $CO_2$, it takes 3.2 min (trout), 9.2 min (carp) and 109.7 min (eel), on average. After slaughter, after three and eight days of storing the fish on ice, the meat quality parameters, pH value, water holding capacity and rigor mortis were measured. $CO_2$ stunning showed the lowest pH-values and water holding capacities; also, rigor mortis in carp and eel advanced most. Testing of raw and prepared fish was performed by a sensoric team. In many cases, fish anaesthetized manually were ranked better than the other groups. The findings indicate that $CO_2$ was not appropriate for stunning carp and eel. Electrical stunning, with some improvements, could meet the requirements of meat quality and animal welfare.
*Descriptors:* processing fishery products, anaesthesia, slaughter, quality, *Oncorhynchus mykiss, Cyprinus carpio, Anguilla anguilla*


Massee KC, Rust MB, Hardy RW, Stickney RR (1995) **The effectiveness of tricaine, quinaldine sulfate and metomidate as anesthetics for larval fish.** *Aquaculture.* 134(3-4):351-359
NAL Call No. SH1A6
Tricaine, quinaldine sulfate, and metomidate were compared as anesthetics for larvae of two species of fish, red drum (*Sciaenops ocellatus*) and goldfish (*Carassius auratus*). Larvae were

exposed to various concentrations of each anesthetic and the percentages of fish reaching stage 4 of anesthesia, post-exposure recovery, and survival were recorded. Effective concentrations were defined as those which induced stage 4 of anesthesia within 3 min after exposure with a recovery time of 10 min or less. Post-exposure survival of 100% was an additional criteria used to define effective anesthetic concentrations. The lowest effective concentration of tricaine for red drum was 55 mg/l (26°C), while 50 mg/l (24°C) was the lowest effective concentration for goldfish. The lowest effective concentration of quinaldine sulfate for red drum was 35 mg/l (26°C), while 60 mg/l (24°C) was the lowest effective concentration for goldfish. Metomidate was found to be an ineffective anesthetic for both red drum and goldfish larvae based upon survival and recovery times. Mortality occurred in red drum larvae at all tested concentrations of metomidate. Larvae of both species that survived anesthesia with metomidate had longer induction and recovery times compared to larvae exposed to tricaine and quinaldine sulfate.
*Descriptors:* fish larvae, anesthetics, survival, *Sciaenops ocellatus, Carassius auratus*, tricaine, quinaldine sulfate, metomidate


Matthews GM, Paasch NN, Achord S, McIntyre KW, Harmon JR (1997) **A technique to minimize the adverse effects associated with handling and marking salmonid smolts.** *Progressive Fish Culturist.* 59(4):307-309
NAL Call No. 157.5 P94
A system that allows anesthetization of juvenile salmonids before netting during a handling and marking operation is described. Our purpose for designing the system was to reduce or minimize any debilitating effects associated with these activities. When compared with smolts handled and marked in the traditional manner, use of the technique resulted in a significant reduction in the mortality of naturally migrating smolts of spring-summer chinook salmon Oncorhynchus tshawytscha during a posthandling and marking seawater challenge performance test. The treatment resulted in lower, but not significantly lower, plasma cortisol levels; however, sample sizes may have been too small for statistical verification. With a little ingenuity, the technique should be adaptable to most smolt handling or marking operations.
*Descriptors:* smolts, aquaculture techniques, marking, anaesthesia, fish culture, fish handling, biological stress, *Oncorhynchus tshawytscha*


Mazur CF, Boreham A, McLean W, Iwama GK (1991) **Rectified wide band white noise as an electroanaesthesia waveform for use with rainbow trout (*Oncorhynchus mykiss*).** *ICES Council Meeting Papers, ICES, Copenhagen (Denmark).* 28 pp.
Rectified and pulsed wide band white noise shows promise as an effective waveform for use in salmonid electroanaesthesia. The use of electroshocking for the capture of fish has often resulted in muscular tetany and vertebral displacement leading to paralysis and death. Wide band white noise used in mammalian electroanaesthesia has been shown to reduce

muscular tetany and was tested here for use with salmonids. Trials on rainbow trout (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) revealed that pulsed rectified wide band white noise (5-30 KHz), produced by a noise generator and a wide band amplifier, induced anaesthesia and reduced, but did not eliminate, damaging tetanic contractions.
*Descriptors:* anaesthesia, electrophysiology, *Oncorhynchus mykiss*, *Oncorhynchus kisutch*, INE, Canada, British Columbia


Mazur CF, Yesaki TY, Iwama GK (1991) **Improvements on the use of two alternatives to chemical anaesthesia for fish: Electroanaesthesia and $CO_2$ anaesthesia.** *Ices Council Meeting Papers, Ices, Copenhagen (Denmark).* 1 p.
There is an increasing need for the use of non-chemical anaesthesia for fish cultured for food as well as for wild fishery enhancement. This need arises from the potential impacts of chemicals on the environment, as well as the requirement to reduce chemical residues in food fish. This paper describes work that we have conducted in the refinement of the use of two alternatives to chemical anaesthetics. While both electroanaesthesia and $CO_2$ anaesthesia have been used for fishery and aquaculture purposes, both have drawbacks in their use in fish. Severe muscle tetany can result from electroanaesthesia, often resulting in spinal dislocation and muscle hemorrhaging. $CO_2$ anaesthesia causes irritation and a struggle response in exposed animals.
*Descriptors:* anaesthetics, bioaccumulation, tissues, environmental impact, aquaculture effluents, Oncorhynchus


McNeil FI, Crossman EJ (1979) **Fin clips in the evaluation of stocking programs for muskellunge, *Esox masquinongy*.** *Transactions of the American Fisheries Society.* 108 (4):335-343
NAL Call No. 414.9 AM3
During laboratory and field experiments in Ontario, with hatchery muskellunge 90-235 mm in total length, total removal of a fin did not add to the immediate mortality caused by seining the fish from ponds. The use of an anesthetic during surgery (MS-222) did not affect subsequent survival of marked, stocked fish. Removal of any single paired fin was equally detrimental to short-term (3 months) survival. In contrast, over long periods (10 months) the loss of a pectoral fin was more detrimental than loss of a pelvic fin. Removal of both fins of a pair may cause higher mortality than the removal of one fin. Neither the fin removed nor the anesthetic significantly affected short-term or long-term growth. Within 1 year of marking regeneration of amputated fins was such that recognition of marked fish was difficult and the degree of difficulty increased with time. Estimates based on marked 2-year-old or older individuals could rsult in substantial underestimates of survival.
*Descriptors:* stocking (organisms), tagging mortality, *Esox masquinongy*, tagging, mortality

causes, anaesthetics, survival, Esocidae, Pisces


McVicar AJ, Rankin JC (1983) **Renal function in unanaesthetized river lampreys (*Lampetra fluviatilis* L.): Effects of anaesthesia, temperature and environmental salinity.** *Journal of Experimental Biology.* 105:351-362
NAL Call No. 442.8 B77
Improved estimates of urine flow rates of lampreys in various salinites were obtained by the collection of urine for periods of up to 48 h from minimally-stressed, unanaesthetized fish, following catheterization of the urinogenital papilla. Urine flow rate in unanaesthetized fish was extremely sensitive to rapid (6°C/hour) changes in temperature and $Q_{10}$ (6-16°C) was approximately 5. Urine flow rate decreased rapidly as the osmotic difference between the body fluids and environment approached zero, and the rate of flow in 30% seawater lampreys was only 7 multiplied by 6% that of freshwater fish. Present data compare favourably with data obtained previously from anaesthetized animals, indicating that renal function in lampreys is not significantly impaired by light MS222 anaesthesia.
*Descriptors:* urine, excretion, temperature effects, salinity effects, anesthetics, *Lampetra fluviatilis*


Mgbenka BO, Ejiofor EN (1998) **Effects of Extracts of Dried Leaves of Erythrophleum suaveolens as Anesthetics on Clariid Catfish.** *Journal of Applied Aquaculture.* 8(4):73-80
NAL Call No. SH135 J69
The effects of crude extract, pure extract, aqueous fraction of pure extract and lipid fraction of pure extract of air-dried leaves of *Erythrophleum suaveolens* as anesthetic on African sharptooth, *Clarias gariepinus*, and the African vundu catfish, *Heterobranchus longifilis*, fingerlings were studied. They were exposed to various doses of the extracts in tanks. The time for each fish to reach anesthesia were recorded. The two clariids were anesthetized in up to 3.5 g/L crude extract and recovered in the fresh water. Soaking the leaves for 24 hours or 48 hours produced no significant difference ($P > 0.05$) in the time to reach anesthesia for the African vundu catfish. These fingerlings reached anesthesia in significantly shorter time ($P < 0.05$) (24.5 minutes at 2.4 g/L concentration) in the pure unseparated extract than in the crude extract (70.5 minutes at 2.4 g/L concentration). All fingerlings exposed to 4 g/L extracts did not recover. Those exposed to less than 3.5 g/L of plant material were anesthetized and recovered only to die later within 24 hours. The time to reach anesthesia decreased with an increase in concentration of the plant extract. Of the two fractions, only the lipid fraction had anesthetizing effect on fish. It, however, took longer to produce the effect than the unseparated pure extract. The aqueous fraction of the pure extract and the control produced no observable anesthetic effects on the fish within 180 minutes. This suggests that the anesthetizing active ingredient resided in the lipid fraction but some factor in the aqueous layer was necessary to quicken its action. Similar

results were got with the sharptooth catfish. Since the fingerlings died after recovering from anesthesia it was concluded that the safety margin of *E. suaveolens* for fingerlings was very narrow at the concentrations used. It is, therefore, not recommended for use on the fingerlings of the clariid catfishes.
*Descriptors:* fish culture, anaesthetics, fish handling, biological stress, *Erythrophleum suaveolens, Clarias gariepinus, Heterobranchus longifilis*


Milton P, Dixon R.N (1980) **Further studies of the effects of the anaesthetic quinaldine on the physiology of the intertidal teleost *Blennius pholis*.** *Journal of the Marine Biological Association. UK.* 60(4):1043-1051
NAL Call No. 442.9 M331
Marked reductions in oxygen consumption were noted in high concentration of quinaldine (10 and 20 ppm), and both entry into anaesthesia and recovery from it were rapid. A period of enhanced oxygen consumption followed anaesthesia, except in the lowest concentration of quinaldine (1 ppm). Experiments conducted over a 4 h period with three different salinities (100, 30 and 10% sea water) indicated that, under the influence of 10 and 20 ppm quinaldine solutions, the fish more resembled an osmoconformer than an osmoregulator. During anaesthesia, water was lost osmotically in 100% sea water, and gained in the more dilute salinities, although it was possible that some osmotic regulation continued. Physiological measurements indicated that quinaldine is suitable for the capture and marking of fish; for surgical procedures it should be mixed with another anaesthetic, for example MS-222, due to the retention of a response to vibratory stimuli.
*Descriptors:* anaesthetics, oxygen consumption, *Blennius pholis*, acclimatization, intertidal environment, Blenniidae, Pisces


Mishra BK, Kumar D, Mishra R (1983) **Observations on the use of carbonic acid anaesthesia in fish fry transport.** *Aquaculture.* 32(3-4):405-408
NAL Call No. SH1A6
Observations are reported on the use of carbonic acid anaesthesia in fish fry transport. The results indicate that live fry of *Labeo rohita* (Ham.) could be kept safely (with 95% survival) in the transport medium under a dose of 500 ppm of carbonic acid for as long as 215 h. Controls survived for only < 106 h.
*Descriptors:* stocking (organisms), fish larvae, anaesthetics, carbonic acid, survival, *Labeo rohita*


Morales AE, Garcia-Rejon L, Higuera Mde la, Billard R, Pauw Ndec (1989) **Use of anaesthesia in situ for handling stress suppression in rainbow trout.** *Aquaculture Europe '89. Short Communications and Abstracts of Review Papers, Films/Slideshows and Poster Papers, Presented at the International Aquaculture Conference held in Bordeaux, France, 2-4 October, 1989, 1989, Special Publication, European Aquaculture Society*.

10:173-174
NAL Call No. SH138.S64
The findings are presented of experiments conducted to determine the effects of in situ anaesthetization of cultured rainbow trout (*Oncorhynchus mykiss*) on suppressing stress caused by routine laboratory handling of the fish. It is suggested that anaesthetics may be used to avoid stress responses under laboratory conditions, but not in fish farms.
*Descriptors:* laboratory culture, fish handling, biological stress, anaesthesia, *Oncorhynchus mykiss*, fish culture


Munday PL, Wilson SK (1997) **Comparative efficacy of clove oil and other chemicals in anaesthetization of *Pomacentrus amboinensis*, a coral reef fish.** *Journal of Fish Biology.* 51(5):931-938
NAL Call No. QL614 J68
The efficacy of quinaldine, benzocaine, MS-222, 2-phenoxyethanol and clove oil was compared for anaesthetizing settlement stage Pomacentrus amboinensis, a frequently studied coral reef fish. Induction to anaesthesia, behaviour during anaesthesia, recovery times and survival rates of fish treated with the different chemicals were compared. Clove oil was only marginally less effective than quinaldine and was more effective than other chemicals tested, except at high concentrations. In addition, fish exposed to clove oil exhibited a much calmer induction to anaesthesia than fish exposed to quinaldine. Therefore, clove oil may be an effective alternative to quinaldine as a fish anaesthetic. Recovery time after anaesthesia with clove oil was two to three times longer than recovery from other chemicals, a desirable characteristic for use in field studies. Survival rates were excellent for all chemicals.
*Descriptors:* anaesthesia, marine fish, coral reefs, survival, developmental stages, anesthetics, *Pomacentrus amboinensis*, clove oil, quinaldine, Pallid damselfish


Muzinic R (1970) **On the use of anaesthetics in the transportation of sardines.** *Studies and Reviews of the General Fisheries Council of the Mediterranean.* 47:1-23
The rate of mortality of non-selected sardines, exposed to 1:150,000 conc of tricaine methane sulfonate in open-system experiments increased rapidly and after 2 hr, by far exceeded 50 per cent. The mortality rate of the fish slowed down considerably when the sardines were transferred to a fresh anaesthetic solution at 30 min intervals using a conc of 1:150,000 tricaine methane sulfonate or compressed air when the temps were 20.8°C and 21.7°C; transferring the sardines had the same effect on their mortality using chloral hydrate at both 1:1,000 and 1:3,000 concs and the effect was even more notable at the latter concs. Similar procedure may be applied in transporting sardines, especially from distant localities for tagging and other experimental work. It is possible that some changes in the

composition of the anaesthetic solution during the initial phase of transportation may be useful. With changes in the anaesthetic solution being made at 30-min intervals, lower concs of chloral hydrate were more advantageous. In standard anaesthesia experiments however, this was not so. In standard anaesthesia experiments with chloral hydrate, a rapid increase in mortality occurred at a decline of the $O_2$ conc to a point below 2 cc/1. In open system standard anaesthesia experiments using 1:150,000 tricaine methane sulfonate conc, the last sardine died at a temp ranging from 20.3°C to 22.8°C and at a mean final $O_2$ value of 0.56 + or - 0.46 cc/1. Chloral hydrate at 1:3,000 and 1:5,000 concs (and perhaps even lower ones) may replace tricaine methane sulfonate in transporting the sardines. The delicate state of the fish was shown by a marked variability of the mortality course within all the series of anaesthesia experiments and by a rather high mean final oxygen value and its great variation.

*Descriptors:* anesthetic, anesthesia, tranport, sardines, chloral hydrate

Nilsen H, Lillehaug A, Taksdal T, Nordmo R (1992) **Toxicity of intraperitoneally injected formalin in Atlantic salmon, *Salmo salar* L.** *Journal of Fish Diseases.* 15(4):323-329
NAL Call No. SH171 A1J68
Atlantic salmon, *Salmo salar* L., parr were injected intraperitoneally with different quantities of formalin (37% formaldehyde) following anaesthetization with either benzocaine (ethyl-p-aminobenzoate) or chlorbutol (1,1,1,-trichloro-2-methyl-2-propanol). The $LD_{50}$ for injected formaldehyde was found to be approximately 50 mg/kg body weight. The type and concentration of the anaesthetic used did not influence mortality rates. Formalin is commonly used to inactivate microorganisms in vaccines. Doses of formalin which were shown to be toxic in this study are close to those which may be injected into fish as a component of various vaccines against bacterial fish diseases. Hence, the formalin content in fish vaccines may well cause mortality under certain conditions.
*Descriptors:* fish diseases, bacterial diseases, disease control, vaccination, fish culture, anaesthesia, *Salmo salar*, Atlantic salmon


Obradovic J (1986) **Effects of anaesthetics (halothane and MS-222) on crayfish, *Astacus astacus*.** *Aquaculture* 52(3):213-217
NAL Call No. SH1A6
The effects of an anaesthetic dispersive in air and usually applied in mammals (halothane, Hoechst) and of an anaesthetic soluble in water and applied in fish (MS-222, Sandoz) were investigated in experiments with crayfish, *A. astacus* (L.). Halothane was used at concentrations of 0.01, 0.06, 0.12, 0.5 and 1.0 vol. %, while MS-222 was applied in two concentrations, dissolved in the ratios of 1:1000 and 1:10,000. Halothane was most effective at 0.5 vol. %. The

concentrations of MS-222 which were applied in the authors experiments had almost no effect on the crayfish.
*Descriptors:* crayfish culture, aquaculture techniques, anaesthetics, *Astacus astacus*, Halothane, MS-222


Oikawa S, Takeda T, Itazawa Y (1994) **Scale effects of MS-222 on a marine teleost, porgy *Pagrus major*.** *Aquaculture* 121(4):369-379
NAL Call No. SH1A6
The relationship between the effective concentration $C_E$ of the anaesthetic MS-222 and body mass was examined at 20°C in porgy ranging in size from 0.00022 g (just after hatching) to 320 g (595 days old). $C_E$ was defined as the concentration which required 3-5 min to induce deep anaesthesia in the fish. Values of $C_E$ (ppm) increased monophasically with increasing body mass (W in g), following the equation $C_E$ = 79W super(0.0549) (N = 30, r = 0.936 between log $C_E$ and log W). The recovery ratio (R sub(R) in %), i.e., the number of fish as a percentage which recovered after being placed back in ordinary seawater, varied depending on the developmental stage. R sub(R) was lowest in fish of around 0.01 g (30 days old), corresponding to the transitional stage between the post-larval and juvenile stage, whereas it was highest (nearly 100%) in the pro-larval stage (about 0.00023 g in size and 0-6 days of age).
*Descriptors:* anesthetics, body size, recovery, fish culture, *Pagrus major*, anaesthesia, MS-222


Olsen YA, Einarsdottir IE, Nilssen KJ (1995) **Metomidate anaesthesia in Atlantic salmon, *Salmo salar*, prevents plasma cortisol increase during stress.** *Aquaculture* 134 (1-2):155-168
NAL Call No. SH1A6
Atlantic salmon (*S. salar*) parr (58 g) in fresh water at 5.0°C and adult salmon (1130 g) in sea water at 7.7°C were exposed to water containing different concentrations of metomidate in the range 1 to 10 mg/l. Metomidate was efficacious in inducing anaesthesia (hypnosis), and efficacy increased with concentration over the interval tested. The anaesthetic was more potent in the adult salmon acclimated to sea water than in freshwater parr. Metomidate at 3 mg/l or higher completely prevented any plasma cortisol increase after a handling stressor when stressor and anaesthetic were applied concomitantly. The lack of a cortisol response seemed to be due to a blockage at the level of the interrenal cell, since exogenous ACTH injected intraperitoneally did not produce a cortisol increase in metomidate-anaesthetized fish but did in those anaesthetized with MS-222. Blood lactate levels and haematocrit increased in fish during metomidate anaesthesia.
*Descriptors:* fish culture, marine aquaculture, freshwater aquaculture, biological stress, anaesthetics, haematology, anadromous species, *Salmo salar*

Ortun J, Esteban MA, Meseguer J (2002) **Effects of phenoxyethanol on the innate immune system of gilthead seabream (*Sparus aurata* L.) exposed to crowding stress.** *Veterinary Immunology and Immunopathology.* 89(1-2):29-36
NAL Call No. SF757.2.V38
Phenoxyethanol is routinely used in seabream aquaculture to minimise fish stress response despite the secondary negative effects which have been observed. In this study, two different doses (60 and 200 mu l/l) of phenoxyethanol, sedative and narcotic, were tested for their ability to reduce the stress caused in gilthead seabream (*Sparus aurata* L.) by crowding. Blood glucose and serum cortisol concentrations were measured as stress indicators. In order to study the effects of the treatment on the innate immune system of crowded specimens, two parameters of the innate immune response, serum complement activity and phagocytosis, were assessed. The results show that anaesthesia itself produced a stress response in the fish and affected the immune system, although the effects were greater with the narcotic dose. When the effects of anaesthesia on crowded fish were analysed, the results pointed to a slight reduction in stress as a result of the sedative dose of phenoxyethanol (lower increase in cortisol and lower reduction in phagocytosis). However, additive negative effects were seen in crowded fish when the narcotic dose of phenoxyethanol was used. Since the use of phenoxyethanol is a common practice in aquaculture, the significance of the results should be considered.
*Descriptors:* drugs, anaesthetics, biological stress, immunity, stocking density, fish culture, complement, phagocytosis, anesthesia, stress, glucose, hydrocortisone, aquaculture, fish immunity, phenoxyethanol, *Sparus aurata*, phenoxyethanol, gilthead seabream, crowding


Ortuno J, Esteban MA, Meseguer J (2002) **Effects of four anaesthetics on the innate immune response of gilthead seabream (*Sparus aurata* L.).** *Fish & Shellfish Immunology.* 12(1):49-59
NAL Call No. QL638.97.F55
Anaesthesia may depress the immune system in mammals, but there is no available information on this topic in fish. In the present work, four anaesthetics that are used in aquaculture, MS222 (0.19 mm), benzocaine (0.21 mm), 2-phenoxyethanol (1.6 mm) and quinaldine sulphate (0.083 mm), were tested in order to observe their effects on the gilthead seabream (*Sparus aurata* L.) innate immune system. The results showed that the four anaesthetics produced increased blood glucose levels after an hour. In addition, benzocaine and 2-phenoxyethanol depressed complement activity and phagocytosis, while MS222 and quinaldine sulphate did not. Some anaesthesia is a common practice in aquaculture, the data obtained should be taken into account to avoid possible immunodepression in farmed fish. Copyright 2002 Academic Press
*Descriptors:* immune response, anesthetics, glucose, blood levels, phagocytosis, fish culture, cultured organisms, marine fish, fish physiology, disease resistance, husbandry diseases, immunity, haematology, anaesthesia, fish immunity, benzocaine, 2-phenoxyethanol, quinaldine sulfate, *Sparus aurata*, gilthead seabream, immunodepression, blood glucose levels, MS222

Ortuno J, Esteban MA, Meseguer J (2002) **Lack of effect of combining different stressors on innate immune responses of seabream (*Sparus aurata* L.).** *Veterinary Immunology and Immunopathology*. 84(1-2):17-27
NAL Call No. SF757.2.V38
A complex stressful event, which commonly occurs in modern aquacultural practices, was broken down into factors that were analysed both individually and jointly to assess their effect on two stress indicators (blood glucose and serum cortisol levels) and two activities of the innate immune response (serum complement and head-kidney leukocyte respiratory burst). For this, gilthead seabream (*Sparus aurata* L.) specimens were exposed to the following stressors: physical disturbance, crowding, anaesthesia with 2-phenoxyethanol and air exposure. At 0, 1, 2, 3 and 4 days post-stress, blood and serum samples were collected to measure glucose concentration and cortisol and complement levels, respectively. Head-kidney leukocytes were isolated and assayed to evaluate respiratory burst activity. The results show that physical disturbance, crowding and anaesthesia produced an occasional increase in glucose and cortisol concentrations. Crowding and anaesthesia induced a depression in complement activity, while hypoxia by air exposure caused a reduction in the respiratory burst. When all factors were jointly applied both humoral and cellular defenses were compromised and cortisol values remained high throughout the experimental period. Any long-term effects of this abnormal serum cortisol levels on the immune system remain unknown.
*Descriptors:* fish immunity, leukocytes, 2-phenoxyethanol, glucose, cortisol, immunity, biological stress, stocking density, anaesthesia, air exposure, defense mechanisms, handling, aquaculture techniques, *Sparus aurata*, gilthead seabream, cortisol


Osanz Castan E, Esteban Alonso J, del Nino Jesus A, Josa Serrano A, Espinosa Velazquez E (1993) **Study on quinaldine and 2-phenoxyethanol anaesthetics: Age and specie influence.** *Actas del IV Congreso Nacional de Acuicultura., Centro de Investigaciones Marinas, Pontevedra (Spain*). pp. 737-742
We have studied the 2-phenoxyethanol and quinaldine effect on adult and fry carp and the 2-phenoxyethanol effect on adult tench (*Tinca tinca*) and carp (*Cyprinus carpio*). We have used different temperatures (10°C in winter and 20°C in summer) and exposure time (1', 3', 5'. 7' and 10' minutes). Anaesthetic doses employed are: 0.1, 0.2, 0.35 and 0.5 ml/l in 2-phenoxyethanol and 0.0125, 0.0250, 0.0375 and 0.05 ml/l in quinaldine.
*Descriptors:* fish culture, anaesthesia, serological studies, blood, temperature, fry, *Tinca tinca, Cyprinus carpio,* 2-phenoxyethanol


Peres G, Roche H, Skrzynski J (1989) **The importance of hematological modifications of a biochemical nature provoked by anesthesia in the fish.** *Bulletin de l'Academie Veterinaire de France.* 62(2):259-272
NAL Call No. 41.9 R24
Results of an experimentation using MS222 (Tricain Methane Sulfonate) in the case of the sea

fish *Dicentrarchus labrax* and bibliographic data show that anaesthesia can induce more or less great modifications of the biochemical hematology in function of utilization. It may induce three kinds of consequence; a transient alteration of the sanitary state; an interaction with some experimental process which might be erroneous; an eventual incidence upon animal or human consumers which justifies precautions concerning alimentary utilization.
*Descriptors:* haematology, biochemical composition, human food, *Dicentrarchus labrax*, anaesthetics, MS222


Plumb JA, Schwedler TE, Limsuwan C (1983) **Experimental anesthesia of three species of freshwater fish with etomidate.** *Progressive Fish Culturist.* 45(1):30-33
NAL Call No. 157.5 P94
Etomidate (ethyl-1-methylbenzyl-imidazole-5-carboxylate) is an experimental non-barbiturate hypnotic agent used intravenously for anesthetic induction in humans and domestic or laboratory mammals. Three species of fish (golden shiners, *Notemigonus crysoleucas* ; striped bass, *Morone saxatilis* ; and channel catfish, *Ictalurus punctatus*) were anesthetized for up to 96 h with various concentrations of etomidate. Mortality during the 48-h recovery period after anesthesia was low in all species of fish. Two-year-old channel catfish withstood from 0.4 to 3.6 mg/L for 80 min with low mortality at the higher concentrations, but anesthesia was induced at 0.8 to 1.2 mg/L. Etomidate compared favorably to quinaldine and tricaine methanesulfonate under the conditions tested.
*Descriptors:* anesthetics, experimental research, *Notemigonus crysoleucas*, *Morone saxatilis*, *Ictalurus punctatus*, etomidate


Post G (1979) **Carbonic acid anesthesia for aquatic organisms.** *Progressive Fish Culturist.* 41(3):142-144
NAL Call No. 157.5 P94
Carbonic acid in water is a safe, inexpensive, effective, convenient, and easily obtainable anesthetic for fish and other aquatic organisms. Carbonic acid is not a controlled substance in the United States, and may not require US Food and Drug Administration registration. Baths containing 150 to 600 mg/l carbonic acid (HSUB-2 COSUB-3) will anaesthetize fish; lower concentrations anaesthetize more slowly and less deeply, high concentrations act more rapidly and with greater sedation. The length of time that fish or aquatic organisms can safely be held in anaesthetizing baths depends on the carbonic acid concentration, and is longer at low concentrations than at high concentrations. A convenient procedure for developing known concentrations of carbonic acid in anaesthetizing baths involves adding equal volumes of 6.75% (wt/vol) sodium bicarbonate solution and 3.95% (wt/vol) of concentrated (97-98%) sulphuric acid solution to a known volume of water.
*Descriptors:* anaesthetics, carbonic acid

Prihoda J (1979) **Experience with use of propoxatein anaesthesia and transport of salmonids in Slovakian fishery union centres.** *Biologizace a Chemizace Zivoicisne Vyroby Veterinaria.* 15(3):283-288
NAL Call No. SF1.B5
Following previous tests, anaesthetic Propoxat of Janssen Co. was introduced into the fishery practice in all the centres of Slovakian Fishery Union during the spawning period of breeding fishes. To facilitate the application, 1% solution dosed 1 ml per 5L water (solution 1:500,000) is used in practice. With view to the size of the medicated basin, 30 to 50 fish are narcotized and after 2.5 min they are transferred to a canvas cradle and spawned, while another batch of fish is put into the basin. The solution is changed after 8 bathes. In the course of the five-year usage no mortality was recorded owing to anaesthesia. In testing an appropriate Propoxate concentration and the method of transporting fish, hermatically closed polyethylene tanks containing 20 l of transporting solution with Propoxate diluted 1:8,000,000 and filled with 16 kg of fish and 20 l of oxygen approved their suitability for this purpose. No negative changes ere found after a two hour transport, while 850 heads out of 5,000 control rainbow trouts died during the classical transport in aerated water.
*Descriptors:* fish culture, spawning, anasthetics, anaesthesia, induced breeding, Salmonidae, Czechoslovakia


Prince A, Powell C (2000) **Clove Oil as an Anesthetic for Invasive Field Procedures on Adult Rainbow Trout.** *North American Journal of Fisheries Management.* 20(4):1029-1032
NAL Call No. SH219.N66
Clove oil has recently been proposed as an appropriate anesthetic for researchers to use on food fish; however, its use in invasive procedures has not yet been reported for salmonids. In a telemetric investigation, we found the concentration of clove oil required for invasive procedures to be 30 mg/L, which is 75% less than previously suggested dosages to achieve and maintain a level of deep anesthesia in adult rainbow trout *Oncorhynchus mykiss* (N = 20). Mean time (" SE) to achieve level 4 anesthesia was 3.7 " 0.9 min. Average exposure time to the anesthetic (surgery time) was 5.8 " 0.2 min, and average recovery time (the time required to regain equilibrium and full swimming mobility) was 4.9 " 1.0 min. Lengthy recovery times (up to 18 min) were observed; such times are typically reported for clove oil. Field investigators should conduct preliminary trials to determine the appropriate concentration of clove oil for their conditions, particularly if the application requires more than 5 min of exposure to the anesthetic.
*Descriptors:* anaesthetics, bioassays, adults, *Oncorhynchus mykiss*, clove oil, Rainbow trout

Puceat M, Garin D, Freminet A (1989) **Inhibitory effect of anaesthesia with 2-phenoxyethanol as compared to MS222 on glucose release in isolated hepatocytes from rainbow trout (*Salmo gairdneri*).** *Comparative Biochemistry and Physiology*. 94A (2):221-224
NAL Call No. QP1 C6
Glucose production by freshly isolated hepatocytes from rainbow trout was studied after anaesthesia of the animals with 2-phenoxy ethanol or tricaine methanesulphonate. At the end of the procedure hepatic contents of glycogen, glucose, lactate, ATP, ADP, AMP, were not significantly different between the two treatments.
*Descriptors:* liver, cells, inhibitors, anaesthesia, *Salmo gairdneri*, fish culture, fish physiology, biochemical phenomena, glucose, hepatocytes, 2-phenoxyethanol, modulation, release


Rivera Lopez H, Orbe Mendoza A, Ross LG (1991) **Use of xylocaine, potentiated with sodium bicarbonate, as an anaesthetic for fry and juveniles of acumara, *Algansea lacustris* Steindachner 1895, from Lake Patzcuaro, Michoacan, Mexico.** *Aquaculture and Fisheries Management.* 22(1):15-18
The effectiveness of xylocaine anaesthesia, potentiated with sodium bicarbonate, was investigated on the altiplano cyprinid, *Algansea lacustris* Steindachner. The drug gave excellent sedation, handling and recovery and was effective at doses between 50 and 300 mg/l in 1 g/l sodium bicarbonate.
*Descriptors:* fish handling, anaesthesia, aquaculture techniques, *Algansea lacustris*, fry, juveniles, Mexico, Michoacan, Patzcuaro Lake, drugs, fish culture, xylocaine, sodium bicarbonate


Ross LG, Ross B (1999) *Anaesthetic and Sedative Techniques for Aquatic Animals*. Blackwell Science, Oxford (UK). 76 pp.
NAL Call No. SH156.9 R67 1999
The handling of fish and other aquatic animals in an out of their natural environment is always difficult. Their struggling has strong effects on their physiology and behaviour and the animals can easily be damaged. Anaesthesia and sedation are therefore essential techniques in fisheries management and aquaculture to minimize stress and physical damage caused by crowding, capture, handling and release. This new text fulfils a proven need for an illustrated, practical guide for workers in aquaculture and fisheries research and management. Based on first-hand experience, the text covers fish, amphibian and reptiles and includes a glossary of drugs, an explanation of major technical terms and an index for ease of reference.
*Descriptors:* disease control, aquaculture, fish diseases, anaesthetics, fish handling

Ross LG, Ross B (1984) *Anaesthetic and Sedative Techniques for Fish***.** Institute of Aquaculture, Stirling (UK), 42 pp.
NAL Call No. SH156.9 R6 1984
The purpose of this handbook is to draw together the available information on sedation and anaesthesia of fishes. Both temperate and tropical freshwater species are considered as well as sedation in sea water. While sedation is a a routine and essentially simple procedure it can also be mismanaged. The overall intention is therefore to produce an illustrated, practical guide for workers both in aquaculture and in research.
*Descriptors:* anaesthesia, anesthetics, fish, Pisces


Ross RM, Backman TWH, Bennett RM (1993) **Evaluation of the anesthetic metomidate for the handling and transport of juvenile American shad.** *Progressive Fish Culturist* 55 (4):236-243
NAL Call No. 157.5 P94
Juvenile American shad (*Alosa sapidissima*) were exposed to three levels of metomidate (0.0 = control, 0.5, and 1.0 mg/L) and three types of sedation or handling (none, sedation only, and handling after sedation) to determine the efficacy and safety of the drug for use in transport and handling of this species. Mean sedation times were 9 and 3 min, and mean recovery times were 6 and 7 min, respectively, for the 0.5- and 1.0-mg/L concentrations of metomidate. For fish exposed to 1.0 mg metomidate/L, normal swimming behavior was delayed as long as 4 h after fish were placed in drug-free water. Aggregating and parallel orientation behaviors, precursors of normal schooling, were significantly reduced at the highest drug level for 1 h, but not for 24 h, after recovery. No posttreatment difference in behavior was observed as a result of handling fish (removal from water, weighing, and measuring) under sedation. Long-term (50-d) survival was not affected by drug concentration in one experiment and was improved by use of the anesthetic in a second study. Metomidate appears to be useful and safe for the transportation and handling of juvenile American shad.
*Descriptors:* anaesthetics, handling, transport, juveniles, *Alosa sapidissima*, metomidate


Roubach R, De Carvalho Gomes L, Val AL (2001) **Safest level of tricaine methanesulfonate (MS-222) to induce anesthesia in juveniles of matrinxa, *Brycon cephalus*.** *Acta Amazonica.* 31(1):159-163
NAL Call No. QH7.A2
The use of MS-222 as an anesthetic for matrinxa juveniles was investigated. At dosage of 100 mg/L or lower fish did not achieve a complete anesthesia state. At 150 mg/L, MS-222 induced anesthesia within 36 seconds and recovered from a 10 minutes period of anesthesia within 5.2

min. Higher concentrations (200, 250 and 300 mg/L) anesthetized fish in lesser times, with the offset of mortality (16.7 and 33.3%) at the 200 and 300 mg/L MS-222 doses, respectively. The only significant differences observed in the hematological parameters, was for the glucose values in fish anesthetized with 250 and 300 mg/L. From the results, the recommended dose of MS-222 for handling matrinxa juveniles is 150 mg/L.
*Descriptors:* anaesthetics, anaesthesia, juveniles, fish handling, *Brycon cephalus*, tricaine methanesulfonate


Sado EK (1985) **Influence of the anaesthetic quinaldine on some tilapias.** *Aquaculture.* 46(1):55-62
NAL Call No. SH1A6
Three species of tilapia, *Sarotherodon melanotheron* and *Sarotherodon guincensis* from brackish water and *Oreochromis (Sarotherodon) noloticus* from fresh water, were exposed to different concentrations of the anaesthetic quinaldine to determine the safe level for handling and transportation of these species. Dosages of quinaldine for handling fish for experimental work and for transportation are given with the proviso that the anaesthetization is carried out under conditions of salinity and temperature which are suitable for acclimation.
*Descriptors:* anesthetics, live storage, *Sarotherodon melanotheron*, *Sarotherodon guincensis*, *Oreochromis niloticus*, environmental factors, quinaldine


Sandodden R, Finstad B, Iversen M (2001) **Transport stress in Atlantic salmon (*Salmo salar* L.): anaesthesia and recovery.** *Aquaculture Research.* 32(2):87-90
NAL Call No. SH1 F8
The effects of metomidate anaesthesia on levels of plasma cortisol, glucose, haematocrit and chloride in Atlantic salmon (*Salmo salar* L.), after a 2-h transport and during a 48-h recovery period were investigated. The use of metomidate anaesthesia during transport led to a reduced release of cortisol and significantly lower levels of plasma cortisol after a 48-h recovery period. Plasma glucose did not return to basal level after a 48-h recovery period, indicating that even longer recovery may be needed for the fish to return to a pre-stress state. The results show that metomidate anaesthesia combined with a recovery period lessens the stress burden imposed by hauling and transport.
*Descriptors:* biological stress, anaesthesia, transportation, fish culture, fish physiology, serological studies, *Salmo salar*, Atlantic salmon


Sayer MDJ, Cameron KS, Wilkinson G (1994) **Fish species found in the rocky sublittoral during winter months as revealed by the underwater application of the anaesthetic quinaldine.** *Journal of Fish Biology.* 44(2):351-353
NAL Call No. QL614 J68

Using the anaesthetic quinaldine applied underwater, fish species not normally observed in the Scottish rocky sublittoral during the winter months have been recorded, and are listed.
*Descriptors:* check lists, distribution records, marine fish, rocky shores, littoral zone, winter, ANE, British Isles, Scotland, anaesthetics, Pisces, methodology, species composition, coastal waters


Schramm HL Jr, Black DJ (1984) **Anesthesia and surgical procedures for implanting radio transmitters into grass carp.** *Progressive Fish Culturist.* 46(3):185-190
NAL Call No. 157.5 P94
The authors investigated anesthetic and surgical procedures useful for implanting radio transmitters into the body cavity of 1.6-3.7 kg (3.5-8.2 lb) grass carp (*Ctenopharyngodon idella*). Quinaldine was an effective anesthetic for fish at water temperatures < 26ºC (79 ºF); however, it was lethal at concentration necessary to induce and maintain sufficient anesthesia for surgery at water temperatures > 29 ºC (84 ºF). MS-222 was a suitable anesthetic at all water temperatures. Implantation of radio tags through midventral incisions was preferable to implantation through lateral incisions, because there was no danger of puncturing the ovaries of female fish and the operation was more easily performed. Surgical procedures are presented.
*Descriptors: Ctenopharyngodon idella*, biotelemetry, activity patterns, local movements, anaesthesia, surgical implantation


Sekizawa Y, Umemura K, Shimura M, Suzuki A, Kikuchi T (1975) **Residue analyses on 2-amino-4-phenylthiazole, a piscine anesthetic, in fishes 1. A model radiotracer experiment with medaka.** *Bulletin of the Japanese Society of Scientific Fisheries.* 41 (4):449-458
NAL Call No. 414.9 J274
Residue analyses on Super(3)H.2-amino-4-phenylthiazole were performed in medaka (killifish, *Oryzias latipes*).This fish was selected because of its ready application in radiotracer experiments and its marked and unique ability to detoxify the piscine anesthetic, 2-amino-4-phenylthiazole to its N-hexuronyl conjugate. The absorption/excretion balance showed an average 102% recovery indicating that the excretion treatment effectively exhausted the residue from medaka, The 1/2 life for retention of this compd and its N-hexuronyl conjugate in the body of the fish was approx 12-15 hr. The fates of both the anesthetic and its N-hexuronyl conjugate in the fish body were determined separately in a time course survey using TLC radiography. plots for the excretion of the major product, i.e. the conjugate, and the anesthetic per se produced 2 crossing exponential curves suggesting that there are 2 compartmentations of both the conjugate and the anesthetic per se in medaka. A mathematical simulation of the residue was also described.

*Descriptors:* anaesthesia, bioaccumulation, chemical analysis, metabolism, *Oryzias latipes*


Sharma SK, Sharma LL (1996) **Effect of chloral hydrate on metabolic rate of *Labeo rohita* (Ham.) and *Poecilia reticulata* (Peters).** *Journal of the Indian Fisheries Association.* 26:121-125
Comparative impact of chloral hydrate anaesthesia on the metabolic rate of Indian major carp *Labeo rohita* and larvivorous fish *Poecilia reticulata* was assessed. Observation on the oxygen consumption rate (OCR) revealed that in common guppies OCR was substantially low (1.105 and 1.097 mg/g/hr) at 0.1 and 0.25 g/l concentrations of chloral hydrate as against OCR of 1.487 mg/g/hr in the control. Fry *L. rohita* in group showed lower metabolic rates in the control as well as treated conditions as compared to the individuals of this fish. This may be due to sympathetic psychophysiological reflex of grouped fish. Higher dose of chloral hydrate (0.25 g/l) also caused higher OCR probably due to distress. Application of chloral hydrate also favoured lesser release of metabolic wastes (ammonia and carbon dioxide). There was significant positive correlation between time and oxygen consumption, whereas, for time and OCR this relationship was negative. Regression of chloral hydrate doses for OCR and time has also been calculated.
*Descriptors:* anaesthetics, oxygen consumption, freshwater fish, *Labeo rohita, Poecilia reticulata*, India, metabolism, correlation, regression analysis


Shimura M, Sekizawa Y (1975) **Residue analyses on 2-amino-4-phenylthiazole, a piscine anesthetic, in fishes 2. Resolution on chemical structure of the metabolite in medaka.** *Bulletin of the Japanese Society of Scientific Fisheries.* 41(5):529-534
NAL Call No. 414.9 J274
The metabolite of 2-amino-4-phenylthiazole in medaka (killifish, *Oryzias latipes*) was isolated as white crystals from environmental water in which the fish were treated with the anesthetic. Acid hydrolysis of the metabolite gave crystallize 2-amino-4-phenylthiazole and a spot on TLC coinciding with that of D-glucuronic acid. Gas chromatography of the metabolite after methanolysis and trimethylsilylation gave peaks coinciding with those of authentic D-glucuronic acid and 2-amino-4- phenylthiazole. The colour reaction of the metabolite suggested that the conjugation site of these 2 constituents was the primary amino group of the thiazole ring and the aldehyde group of glucuronic acid. Reaction of D-glucuronic acid and 2-amino-4-pheylthiazole in 50% acetone under reflux resulted in the formation of a product identical with the naturally occurring metabolite. The NMR spectrum of the metabolite in D Sub(2)O revealed that the structure of the sugar moiety was {beta}-D-glucopyranosiduronic acid. Thus it was concluded that the chemical structure of the metabolite in medaka should be 2-amino-4- phenylthiazole 2-N-{beta}-D-glucopyranosiduronic acid.
*Descriptors:* anaesthesia, metabolites, *Oryzias latipes*, chemical structure

Sijm DTHM, Bol J, Seinen W, Opperhuizen A. (1993) **Ethyl m-aminobenzoate methanesulfonate dependent and carrier dependent pharmacokinetics of extremely lipophilic compounds in rainbow trout.** *Archives of Environmental Contamination and Toxicology.* 25(1):102-109
NAL Call No. TD172 A7
Significant differences were found in both uptake and pharmacokinetics in fish (*Oncorhynchus mykiss*) when six lipophilic compounds were dosed by gavage in either an oil or an gelatin carrier. Pharmacokinetics were also different when fish were anaesthetized with ethyl m-aminobenzoate methanesulfonate (MS-222) before dosing. The highest uptake percentages, uptake rates and concentrations of the compounds were found in the fish which were given the gelatin carrier only. MS-222 decreased the uptake of the compounds. Absorption of the compounds from oil was lower than from gelatin. In addition, absorption from oil continued for 21 d, which lasted longer than from gelatin.
*Descriptors:* pharmacokinetics, lipids, chemicals, bioaccumulation, absorption, oil, gelatin, liver, diets, *Oncorhynchus mykiss*, tricaine, oils, chemical kinetics, anaesthesia, correlation, absorption coefficient, chlorinated hydrocarbons, freshwater fish, anadromous species


Siwicki A (1984) **New anaesthetic for fish.** *Aquaculture.* 38(2):171-176
NAL Call No. SH1A6
Anaesthetics are needed when handling fish, especially during tagging. However, most anaesthetics applied at present have a strong toxic effect on fish. For this reason it is only permissible to keep fish anaesthetized for a short time. A new anaesthetic “Propanidid” has been successfully tested which allows fish to be anaesthetized for up to 1 h. It can be applied as an intraperitoneal injection and as a bath solution. The required disappearance of sense perception and motor reflexes in the fish can be obtained in 2-4 min. Low toxicity of the pharmacological preparation has been proved according to a full set of the clinical, toxicological, haematological and biochemical criteria. Clinical tests were carried out with salmonids mainly. The new compound belongs to a group of anaesthetics which are used in human medicine; thus, it is considered to be harmless for man as an operator and a consumer.
*Descriptors:* fish culture, aquaculture techniques, anesthetics, fish handling, Propanidid


Siwicki A, Jeney Z (1986) **Surgical intervention in wels (*Silurus glanis* L.) during artificial propagation.** *Aquacultura Hungarica Szarvas [Aquacult. Hung.].* 5:55-58
NAL Call No. SH101 H8A68
Experience obtained during surgical intervention in artificial propagation of wels (*Silurus glanis* L.) is described. Favourable results were obtained when operating the lateral part of fish at a height of testes applying sterile surgical line thread in 0.5 cm sutures. During operations the anaesthetic Propanidid (Polfa, Poland) was successfully applied.
*Descriptors:* fish culture, induced breeding, anaesthesia, *Silurus glanis*, testes, surgery

Smit GL, Hattingh J (1979) **Anaesthetic potency of MS 222 and neutralized MS 222 as studied in three freshwater fish species.** *Comparative Biochemistry and Physiology.* 62C (2):237-241
NAL Call No. QP901 C6
The effects of several different concentrations of MS 222 and neutralized MS 222 on aquarium water quality and anesthetic potency were investigated in *Cyprinus carpio, Sarotherodon mossambicus* and *Salmo gairdneri*. MS 222 caused a decrease in pH and bicarbonate alkalinity with a corresponding increase in $pCO_2$ of the aquarium water. Conductivity was also increased. Neutralized MS 222 prevented, apart from an increase in conductivity, such effects. Increasing the concentration of MS 222 in the aquarium water resulted in a decrease in anaesthetic induction times in all three fish species studied. Neutralized MS 222 induced anaesthesia reduced induction times further and also increased recovery times from anaesthesia. The amount of free MS 222 in the blood of the three fish species studied did not differ significantly from each other per MS 222 concentration employed and showed an increase with increased concentrations of MS 222. With neutralized MS 222 the concentration of free MS 222 in the blood of the three fish species was generally higher. Neutralized MS 222 thus resulted in a deeper, more consistent anaesthesia, thereby indicating a safer, more effective, longer-acting anaesthetic.
*Descriptors:* anaesthetics, Pisces, aquaria, *Cyprinus carpio*, *Sarotherodon mossambicus*, *Salmo gairdneri*, water quality


Smit GL, Hattingh J, Burger AP (1979) **Haematological assessment of the effects of the anaesthetic MS 222 in natural and neutralized form in three freshwater fish species: haemoglobin electrophoresis, ATP levels and corpuscular fragility curves.** *Journal of Fish Biology.* 15(6):655-663
NAL Call No. QL614 J68
The effects of MS 222 and neutralized MS 222 anaesthesia on haemoglobin electrophoresis, erythrocyte adenosine triphosphate (ATP) levels and corpuscular fragility curves were studied in *Cyprinus carpio*, *Sarotherodon mossambicus* and *Salmo gairdneri*. Haemoglobin electrophoresis showed no significant intra-species differences in the percentage composition of the various fractions for any concentration of MS 222 and neutralized MS 222 used. Significant interspecies differences were, however, still observed. ATP levels showed intra- and interspecies differences ascribed to the response of the fish species to MS 222-induced stress and not to actual changes in erythrocyte ATP concentrations. Differences were also observed in corpuscular fragility curves for all three species when using MS 222 or neutralized MS 222 compared to curves obtained without the use of the anaesthetic, but the mechanisms involved are not clear.
*Descriptors:* haematology, anaesthetics, erythrocytes, haemoglobin, *Cyprinus carpio*, *Sarotherodon mossambicus*, *Salmo gairdneri*, Cyprinidae, Salmonidae, Cichlidae, Pisces,

ATP, ethyl <m->aminobenzoate, effects on, fish


Smit GL, Hattingh J, Burger AP (1979) **Haematological assessment of the effects of the anaesthetic MS 222 in natural and neutralized form in three freshwater fish species: interspecies differences.** *Journal of Fish Biology.* 15(6):633-643
NAL Call No. QL614 J68
Interspecies haematological differences to MS 222 and neutralized MS 222 anaesthesia were investigated in *Sarotherodon mossambicus, Cyprinus carpio* and *Salmo gairdneri* acclimated under identical laboratory conditions. Anaesthesia with MS 222 resulted in a 'chemical stress' in all fish, as was evident from changes in the haematological profiles of the animals. Such species variations in the haematology persisted throughout the whole experiment protocol which employed different concentrations of the anaesthetic. The use of neutralized MS 222, whereby aquarium water quality remained unchanged, improved the haematological profile. Possible reasons for the interspecies differences observed are discussed.
*Descriptors:* haematology, anaesthetics, *Cyprinus carpio, Salmo gairdneri, Sarotherodon mossambicus*, Cyprinidae, Salmonidae, Cichlidae, Pisces, fish culture, ethyl m-aminobenzoate, effects on, sedatives, local anaesthetics


Smit GL, Hattingh J, Burger AP (1979) **Haematological assessment of the effects of the anaesthetic MS 222 in natural and neutralized form in three freshwater fish species: intraspecies differences.** *Journal of Fish Biology.* 15(6):645-653
NAL Call No. QL614 J68
The effects of different concentrations of natural MS 222 and neutralized MS 222 were studied on the haematology of *Cyprinus carpio*, *Sarotherodon mossambicus* and *Salmo gairdneri*. As judged from the results, MS 222, which is acidic in nature, produced haemoconcentration effects in all species studied, being least in the trout followed by carp and Sarotherodon mossambicus. These differences are ascribed to acid-base regulatory functions and metabolic activities of the fish species investigated. The use of neutralized MS 222 improved the haematological profiles markedly and resulted in stabilization of acid-base parameters and red blood cells sizes and numbers. Haemoconcentration effects, however, still persisted. Trout were found to be more susceptible to the stress of MS 222 anaesthesia than carp and *Sarotherodon mossambicus*.
*Descriptors:* haematology, anaesthetics, *Sarotherodon mossambicus*, *Salmo gairdneri*, *Cyprinus carpio*, Cichlidae, Salmonidae, Cyprinidae, ethyl-m-aminobenzoate, neutralization, effects on, sedatives, local anaesthetics

Smit GL, Schoonbee HJ, Barham WT (1979) **Some effects of the anaesthetic MS 222 on fresh water.** *South African Journal of Science* 73(11):351-352
NAL Call No. 515 SO84
Previous research has shown that MS 222 (tricaine methanesulphonate) added to water to produce anaesthesia in fish has a variable effect. The possibility that this may be caused by differences in mineral content was investigated in the study reported. MS 222 was added to tapwater, deionized water, distilled water, borehole water and water from a dolomite spring and the pH, $pCO_2$, $pO_2$, orthophosphate content and conductivity was measured at various times up to 1 1/2 h. Results show that because of the changes in pH and conductivity induced in deionized and distilled water, these should not be used in laboratory experiments in the presence of MS 222. The changes, which occur within 2 minutes and continue for at least 30 minutes, could significantly affect the physiology of target fish. However, water with a good buffering ability, such as that from the dolomite spring, was relatively unaffected by MS 222. It is concluded that water with a high mineral content is best suited for the laboratory use of MS 222.
*Descriptors:* anaesthetics, environmental effects, Pisces, physiology


Smith DA, Smith SA, Holladay SD (1999) **Effect of previous exposure to tricaine methanesulfonate on time to anesthesia in hybrid tilapias.** *Journal of Aquatic Animal Health.* 11(2):183-186
NAL Call No. SH171.J68
Tricaine methanesulfonate (MS-222) is one of the most broadly used anesthetic and tranquilizing agents for poikilotherms, and it is currently the only anesthetic approved for use with food fish. To test the preliminary observation in tilapias *Oreochromis sp.* previously exposed to anesthetizing doses of MS-222 that time to anesthesia was shorter on subsequent exposures, hybrids of white tilapias (Nile tilapia *O. niloticus* x blue tilapia *O. aureus*) crossed with Mozambique tilapias *O. mossambicus* were anesthetized with MS-222. Time to anesthesia was recorded at this initial drug exposure and weekly for 6 weeks after initial exposure. Fish previously exposed to MS-222 did not display a significantly reduced time to anesthesia on the second exposure but did display significant reductions at the third exposure and thereafter. These preliminary results suggest that tilapias do not respond to MS-222 with the typical enzyme induction-mediated tolerance reaction commonly seen with anesthetic chemicals in mammals.
*Descriptors:* hybrids, anaesthesia, tolerance, enzymes, oreochromis, tricaine methanesulfonate


Smith MFL (1992) **Capture and transportation of elasmobranchs, with emphasis on the grey nurse shark (*Carcharias taurus*).** *Sharks: Biology And Fisheries., Australian Journal of Marine and Freshwater Research.* 43(1):325-343
NAL Call No. QL638.9 I57 1991
Physiological changes manifest during the capture and transportation of elasmobranchs are discussed. Reference is made to the general adaptation syndrome and to mechanisms of change

in concentrations of blood glucose, blood acid and serum electrolyte. Methods of alleviating these profound changes are suggested, with emphasis on the capture and transportation of the grey nurse shark (*Carcharias taurus*). The hoop method is shown to be a convenient technique for capturing wild grey sharks, and a combination of ketamine hydrochloride and xylazine hydrochloride, with antagonism by yohimbine hydrochloride, is found to provide an acceptable regime of transportation anesthesia. Intravenous administration of sodium bicarbonate and glucose as well as oxygenation of water in the life-support system are shown to be valuable methods of alleviating stress-induced blood acidosis.
*Descriptors:* captivity, transportation, *Carcharias taurus*, biological stress, fish culture, fish handling, anaesthesia


Soivio A, Hughes GM (1978) **Circulatory changes in secondary lamellae of *Salmo gairdneri* gills in hypoxia and anaesthesia.** *Annales Zoologici Fennici.* 15(3):221-225
NAL Call No. 410 AN712
The secondary lamellae of rainbow trout gills from hypoxic and anaesthetized fish were analysed stereologically for the blood volume and haematocrit value. In hypoxia the gills undergo vasodilatation, which is accompanied by slight haemodilution. When oxygen is available the situation changes; there is a tendency to vasoconstriction, but a continuing decrease in the haematocrit value. In anaesthesia the vasodilatation seen in the secondary lamellae is combined with haemoconcentration. During recovery vasodilatation continues, while the haematocrit value falls to below that of controls. Explanations for these observations are offered in terms of the circulation through the gills.
*Descriptors:* respiratory organs, blood circulation, *Salmo gairdneri*, physiology, anaesthesia, hypoxia, blood


Soivio A, Nyholm K, Huhti M (1977) **Effects of anaesthesia with MS 222, neutralized MS 222 and benzocaine on the blood constituents of rainbow trout, *Salmo gairdneri*.** *Journal of Fish Biology.* 10(1):91-101
NAL Call No. QL614 J68
Rainbow trout (*S.gairdneri* Richardson) were subjected to 15 min anaesthesia with unbuffered MS 222, neutralized MS 222 and benzocaine with and without physical stress. Blood samples were taken through cannulae inserted into the doral aorta. The Hct values and Hb concns increased with all the anaesthetics, which also caused swelling of erythrocytes. The initial values were restored within 4-12 h of recovery. Each anaesthetic elevated the blood lactate concn, but the initial level was regained within 12 hr. The blood glucose level decreased the most during anaesthesia with unbuffered MS 222, but the initial level was rapidly restored. Benzocaine caused the least hypoglycaemia during anaesthesia, but the subsequent hyperglycaemia, as in the fish anaesthetized with neutralized MS 222, lasted 24 hr. Neutralized MS 222 and benzocaine elevated the plasma $K^+$ concn more

rapidly than unbuffered MS 222. The initial levels were regained in 4 days. All anaesthetics raised the $Mg^{++}$ concn. The $pO_2$ in the dorsal aorta decreased during anaesthesia with unbuffered MS 222 by about 85 mmHg, while the $pCO_2$ increased by about 1.5 mmHg. Their initial levels were regained within 20 min. During anaesthesia the pH value decreased by 0.3 units and returned to the initial value within 2-4 hr of recovery. MS 222 seemed to be an asphyxiant.
*Descriptors:* anaesthesia, blood, biological stress, hypoxia, *Oncorhynchus mykiss*


Soto C (1995) **Clove oil: A fish anaesthetic.** *Window Newsletter. Mombasa.* 6(2):2-3
ISSN: 1024-4158
In experiments in Ambon, Indonesia, clove oil was used successfully to anaesthetise rabbit fish, *Siganus lineatus* in order to measure weight and length. Clove oil which has been used in Indonesia for centuries by humans as topical anaesthetic for toothaches, headaches and joint pains, is a dark brown liquid resulting from distillation of flowers, flower stalks and leaves of clove trees, *Eugenia aromatica*, and contains the compound eugenol. The stock solution of the anaesthetic (10g/l) was prepared by mixing 10ml of clove oil, 'Minyerk Cengkeh Merpati Putih' brand (composition 100% oleum chlorophyll) in one litre of boiled freshwater assuming the density of clove oil is approximately 1.0g/ml). The stock solution was shaken vigorously before mixing with seawater. The concentration of clove oil which fish lost consciousness within 1-1.5 minutes was 100mg/l (30ml stock solution in 3 litres). Fish recovered consciousness quickly, within 3 minutes. Clove oil needs to be assessed as an anaesthetic for fish according to relevant criteria of efficacy, availability, ease of use, cost and side effects on fish, humans and the environment.
*Descriptors:* botanical resources, drugs, anaesthetics, anaesthesia, fish culture, aquaculture, *Siganus lineatus, Eugenia aromatica*, ISEW, Indonesia, clove oil, rabbit fish


Soto CG, Burhanuddin (1995) **Clove oil as a fish anaesthetic for measuring length and weight of rabbitfish (*Siganus lineatus*).** *Aquaculture*. 136(1-2):149-152
NAL Call No. SH1A6
The successful use of clove oil as a fish anaesthetic is described. Juvenile rabbitfish, *Siganus lineatus*, from the same cohort ranging in size from 5 to 23 cm in total length were anaesthetized, and their length and weight were recorded on three separate occasions. Fish fed shortly afterward, and no mortality was observed. Clove oil appears to be highly effective as a fish anaesthetic with potentially few or no side effects. In Indonesia, its use is advantageous because it is locally produced and inexpensive.
*Descriptors:* anaesthetics, *Siganus lineatus*, aquaculture techniques, Indonesia, fish culture, clove oil

Spotte S, Bubucis PM, Anderson G (1991) **Plasma cortisol response of seawater-adapted mummichogs (*Fundulus heteroclitus*) during deep MS-222 anesthesia.** *Zoo Biology* 10 (1):75-79
NAL Call No. QL77.5.Z6
Anesthetics are used to reduce stress in fishes during handling and transfer. However, deep anesthesia of seawater-adapted mummichogs (*Fundulus heteroclitus*) results in a time-related increase in plasma cortisol, indicating a primary (neuroendocrine) stress response. Groups of seven fish were bled within 1 to 12 min of exposure to the anesthetic MS-222. Plasma cortisol rose more rapidly in fish removed from the MS-222 solution immediately after 1 min and held between wet paper towels than in fish that remained immersed. The difference between methods was significant ($P < 0.001$) with variation restricted to the later sampling periods. Differences were not significant in fish sampled immediately after 1 min.
*Descriptors:* serological studies, steroids, biological stress, anaesthetics, *Fundulus heteroclitus*, fish physiology, MS-222


Stabell OB, Aanesen RT, Eilertsen HC (1999) **Toxic peculiarities of the marine alga *Phaeocystis pouchetii* detected by in vivo and in vitro bioassay methods.** *Aquatic Toxicology.* 44(4):279-288
NAL Call No. QH541.5.W3A6
The marine alga *Phaeocystis pouchetii* has recently been shown to display toxic properties towards fish (i.e. cod, *Gadus morhua*) larvae. The assumed toxic principle of this prymnesiophyte was extracted from *Phaeocystis* cultures by filtering and solid phase sorbent techniques. Toxicity testing was carried out by in vitro and in vivo bioassay methods based on blood haemolysis and injection into flies. The active material from the *Phaeocystis* cultures was found within a chemical fraction previously established for the separation of *Chrysochromulina sp.* and *Prymnesium sp.* toxins. The presence of active material was also found in filtered seawater collected during a *Phaeocystis* bloom, confirming that *Phaeocystis* releases the active material into the natural environment. Haemolytic activity was almost absent in the material tested, demonstrating that the toxic principle in *Phaeocystis* is different from that described for other prymnesiophytes. By the fly bioassay method, on the other hand, a rapid response to injected material was obtained, resulting in a high proportion of apparently ‘dead’ flies registered within 1 h. The time scale of response in flies coincided with that previously reported for haemolytic toxins of *Prymnesium parvum*. However, an unexpected response was observed with the *Phaeocystis* material, since some of the flies that were assumed dead regained motility within a 4-h period of monitoring, the portion of awakened flies being inversely related to dose injected. Regained motility was also found with injected material from filtered natural seawater. Accordingly, the proposed toxins released by *Phaeocystis* appear to be compounds that hold anaesthetic properties, possibly expressing toxic effects when presented in surplus

doses. These findings suggest that *Phaeocystis* may primarily be harmful to fish larvae following ingestion.
*Descriptors:* biological poisons, metabolites, anaesthetics, bioassays, seaweeds, fish larvae, algae, toxins, toxicity testing, hemolysis, algal blooms, bioassay, analytical methods, toxicity, marine organisms, larvae, ingestion, aquatic organisms, Pisces, *Phaeocystis pouchetti*, *Phaeocystis pouchetii*, *Gadus morhua*, Atlantic cod


Stech L, Mims SD, Shelton WL, Linhart O (1998) **A modified method for removal of ovulated eggs from paddlefish.** *Aquaculture '98 Book of Abstracts.* p. 367
Paddlefish eggs when ovulated are discharged into the body cavity and exit through one of two ovarian funnels. Two methods are currently practiced in artificial propagation to remove the eggs from an ovulating fish: hand-stripping or caesarean section. Hand stripping is labor intensive often taking 8 to 10 hours to remove the eggs. Caesarean section is a quick method to remove the eggs in 10 to 15 minutes, but often the broodstock do not survive. Because of complications with both methods for egg removal, a new experimental procedure which in minimally invasive was developed for quick removal of eggs from an ovulated paddlefish. Ovulated female was anesthetized with 80 mg/l of MS-222 and placed ventral side up on a stretcher. A finger was inserted into the gonopore to enlarge the opening. A scalpel (no. 11 blade) was carefully inserted into the opening and a 1 to 2 cm incision was made through the oviduct (Mullerian duct) wall. After removal of the scalpel, the incision was probed with an inserted finger to insure that the opening permitted free copyright flow of eggs. The fish was inverted and pressure placed on the abdomen region by two personnel so the eggs flowed out the gonopore. Ten fish were ovulated using this method and time required to remove the eggs was 7 to 10 min/fish. Three of the fish were sacrificed to observe the effect from this method. Only a small quantity of eggs were retained in these fish. The other fish were stocked in ponds without any ill effects and will be used as potential broodstock in the future.
*Descriptors:* fish eggs, methodology, females, seed collection, ovulation, brood stocks, anaesthesia, aquaculture techniques, *Polyodon spathula*, USA, paddlefish


Stehly GR, Gingerich WH (1999) **Evaluation of AQUI-S (efficacy and minimum toxic concentration) as a fish anaesthetic/sedative for public aquaculture in the United States.** *Aquaculture Research.* 30(5):365-372
NAL Call No. SH1 F8
A preliminary evaluation of efficacy and minimum toxic concentration of AQUI-S, a fish anaesthetic/sedative, was determined in two size classes of six species of fish important to US public aquaculture (bluegill, channel catfish, lake trout, rainbow trout, walleye and yellow perch). In addition, efficacy and minimum toxic concentration were determined in

juvenile-young adult (fish aged 1 year or older) rainbow trout acclimated to water at 7°C, 12°C and 17°C. Testing concentrations were based on determinations made with range-finding studies for both efficacy and minimum toxic concentration. Most of the tested juvenile-young adult fish species were induced in 3 min or less at a nominal AQUI-S concentration of 20 mg/L. In juvenile-young adult fish, the minimum toxic concentration was at least 2.5 times the selected efficacious concentration. Three out of five species of fry fingerlings (1.25-12.5 cm in length and < 1 year old) were induced in less than or equal to 4.1 min at a nominal concentration of 20 mg/L AQUI-S, with the other two species requiring nominal concentrations of 25 and 35 mg/L for similar times of induction. Recovery times were less than or equal to 7.3 min for all species in the two size classes. In fry-fingerlings, the minimum toxic concentration was at least 1.4 times the selected efficacious concentration. There appeared to be little relationship between size of fish and concentrations or times to induction, recovery times and minimum toxic concentration. The times required for induction and for recovery were increased in rainbow trout as the acclimation temperature was reduced.
*Descriptors:* anesthetics, sedatives, fish culture, aquaculture techniques, anaesthesia, public health, toxicology, toxicity tests, *Stizostedion vitreum vitreum, Perca flavescens, Oncorhynchus mykiss, Ictalurus punctatus, Salvelinus namaycush, Lepomis macrochirus*, USA, bluegill, rainbow trout, channel catfish, graceful catfish, lake trout, walleye, yellow perch


Stone DS, Tostin N (1999) **Clove bud oil a big yawn for silver perch.** *Fisheries NSW, Sydney.* 2(4):19 ISSN: 1329-8267
Anaesthetics are used in aquaculture to minimize stress and damage to fish during harvesting, grading, transportation, spawning induction and handling. AQUI-S clove bud oil and benzocaine are among some of the anaesthetics currently being considered for use in the silver perch industry. At present, AQUI-S is the only anaesthetic registered with the National Registration Authority for use for food fish in Australia. The required concentration of each of several anaesthetics was evaluated to induce suitable levels of anaesthesia for the handling of silver perch (*Bidyanus bidyanus*) during harvesting or spawning induction. The study determined effective concentrations for three anaesthetics for harvesting and spawning induction for silver perch. All anaesthetics were reliable and easy to use, but clove bud oil was the most efficient and economical. For clove bud oil to be used as an anaesthetic for silver perch in the future, there is an urgent need for its registration with the National Registration Authority.
*Descriptors:* anaesthetics, fish handling, harvesting, anaesthesia, aquaculture techniques, fish culture, biological stress, food fish, *Bidyanus bidyanus*


Strange RJ, Schreck CB (1978) **Anesthetic and handling stress on survival and cortisol concentration in yearling chinook salmon (*Oncorhynchus tshawytscha*).** *Journal of the*

*Fisheries Research Board of Canada* 35(3):345-349
NAL Call No: 442.9 C16J
Brief anesthetization with 50 mg/L buffered MS-222 RegTM (ethyl m-aminobenzoate methanesulfonate) of yearling chinook salmon during mild handling caused no change in plasma cortisol concentrations compared with levels in non-anesthetized fish. Prolonged exposure (180 min) to a depressing dose of buffered MS-222 RegTM (25 mg/L) elevated cortisol more than an immobilizing dose (50 mg/L), while 100 mg/L was lethal within 30 min. Fish anesthetized (50 mg/L MS-222 RegTM) during a severe 30-min handling stress had significantly lower mortality than controls to a second handling stress applied when the fish were no longer anesthetized. Anesthetization during the first stressor also prevented the cortisol stress response evident in the control fish. Anesthetic (with or without buffer) administered before initial capture was most effective at increasing survival during a second stressor, while anesthetic supplied after initial capture may have been slightly less effective. A 0.5% NaCl solution supplied after capture was less effective than any anesthetic treatment in increasing future survival, but was better than no treatment. Saline treatment did not attenuate the cortisol stress response. A rapid method of plasma sample preparation for competitive protein binding assay of cortisol was developed.
*Descriptors:* anaesthetics, fish handling, fatigue (biological), *Oncorhynchus tshawytscha*, survival, blood, bioassays, fishery management, fish culture


Suzuki A, Sekizawa Y (1979) **Residue analyses on 2-amino-4-phenylthiazole, a piscine anesthetic, in fishes. 4. GC/MS analysis on rainbow trout.** *Bulletin of the Japanese Society of Scientific Fisheries.* 45(2):167-171
NAL Call No. 414.9 J274
When a piscine anesthetic, 2-amino-4-phenylthiazole, was absorbed by rainbow trout, *Salmo gairdneri irideus*, from an anesthetic solution, a whole body concentration of 6.7 and 13 ppm was attained at 3 hours and 6 hours, respectively. After anesthetization for 6 hours, fish were transferred into 500 l of fresh water flowing at a rate 2 L per minute. Residues of the anesthetic in the fish were measured by gas chromatography-mass spectrometry (GC/MS). The total concentration of anesthetic in the fish declined at a rate comparable to that predicted by a computed theoretical biexponential curve obtained by a previously described mathematical procedure. The biological half-life of the anesthetic under these experimental conditions was approximately 40 minutes in the primary step and 22 hours in the secondary step. The whole body residues which remained at 24 and 48 hours were 0.1 ppm and 0.05 ppm, respectively.
*Descriptors:* anesthetics, excretion, body burden, biological half life, *Salmo gairdneri irideus*, 2-amino-4-phenylthiazole


Suzuki A, Shimura M, Kikuchi T, Sekizawa Y (1977) **Residue analyses on 2-amino-4-phenylthiazole, a piscine anesthetic, in fishes. 3. Metabolism in rainbow trout and**

**carp.** *Bulletin of the Japanese Society of Scientific Fisheries.* 43(7):837-847
NAL Call No. 414.9 J274
The major biotransformation product of 2-amino-4-phenylthiazole in rainbow trout (*Salmo gairdneri irideus*) was isolated from water following exposure of fish to the anesthetic. The isolated crystalline metabolite was shown by means of ultraviolet, infrared and optical rotatory dispersion spectroscopy and gas chromatography to be identical to 2-amino-4-phenylthiazole-2-N- beta -mono-D-glucopyranosiduronic acid, the major biotransformation product previously found in medaka (killifish, *Oryzias latipes*). The major biotransformation product in carp (*Cyprinus carpio*) was also identified as 2-amino-4-phenylthiazole-2-N- beta -mono-D-glucopyranosiduronic acid by molecular sieve, thin layer and gas chromatography. Conversion of 2-amino-4-phenylthiazole to the N-glucuronyl conjugate was 8 and 12%, respectively, in rainbow trout and carp as shown by thin layer chromatography of extracts from fish treated with $^{3}H$-labeled anesthetic. In addition, a minor metabolite of the anesthetic in rainbow trout was isolated as a yellowish-white crystalline powder and identified as 2-acetamido-4-(4'-hydroxyphenyl)-thiazole by means of ultraviolet and infrared spectroscopy, NMR and mass spectrometry. Chromatography suggested that this same metabolite was also formed in carp but in concentrations too low for isolation and definitive identification.
*Descriptors:* anaesthetics, metabolism, *Salmo gairdneri, Cyprinus carpio*


Svobodova Z, Kalab P, Dusek L, Vykusova B, Kolarova J, Janouskova D (1999) **The effect of handling and transport on the concentration of glucose and cortisol in blood plasma of common carp.** *Acta Veterinaria (Brno).* 68:265-274
NAL Call No. SF604 B7
The aim of this contribution was to assess the degree of stress in common carp (*Cyprinus carpio*, L.) exposed to handling and transport. Cortisol and glucose concentrations in blood plasma were used as stress indicators. In some cases, concentration of ammonia in blood plasma and relative weight of spleen (SSI) were used as well. Within handling, an effect of time pause (0; 2 and 5 min) between catching the fish from water and blood sampling for stress indicators was checked. Another goal was to assess the effect of Menocain anaesthetic on the stress indicators. An open system of a 10-hour transport in a special long-distance live fish transport truck (Transport I a II), and a 2-hour transport in classic transporting tanks (Transport III) were compared. Temperature and oxygen concentration in water was measured during transport. After handling the fish prior to blood sampling (2 and 5 min pause), the cortisol concentration dropped significantly ($p< 0.001$) and the glucose concentration significantly ($p< 0.001$) increased compared to values in fish sampled immediately after catching. No effect of anaesthetics on cortisol concentration was proved. On the contrary, the glucose concentration fell ($p< 0.012$) in the anaesthetized fish. After a 10-hour transport in a special truck (Transport I), a significant ($p< 0.001$) decrease of the cortisol concentration was found, as well as a significant ($p< 0.001$) increase in the glucose concentration in blood plasma. In the course of 10-hour transport in a special truck (Transport II), the majority of carp was found dead. Suffocation and ammonia autointoxication due to loading the fish with full digestive tract were the most probable causes of the fish mortality. After a 2-hour

transport in transporting tanks (Transport III) both the cortisol concentration and relative weight of spleen (SSI) dropped non-significantly while glucose concentration in blood plasma significantly ($p < 0.001$) increased. Results showed that both handling and transport are important stressors in the common carp. Preventive measures were proposed aimed at alleviating the negative effects of these stressors.
*Descriptors:* biological stress, anaesthetics, fish culture, transportation, glucose, blood, ammonia, spleen, *Cyprinus carpio*, cortisol, common carp, European carp, handling stress


Svobodova Z, Valentova V, Kouril J, Vykusova B, Hamackova J (1988) **The comparison of the effect of three anaesthetics on some hematological indicators and acidobasic balance in tench.** *Bulletin of the Fisheries Research Institute, Vodnany.* 24(1):10-17
NAL Call No. SH1 B77
An evaluation of the new Czechoslovak anaesthetic Menocain and a study of its effect on some hematological indicators and acidobasic balance in fish was carried out. The model fish in this comparative trial were female and male brood tench, Tinca tinca, at artificial spawning. In the fish anaesthetized by Menocain, no significant changes in the observed hematological indicators were recorded. On the basis of the carried out investigation with foreign preparations (Propoxate, Propanidide) it can be concluded that the new Czechoslovak anaesthetic Menocain is a very suitable preparation for anaesthesia of carp fish from the aspect of safety.
*Descriptors:* anaesthesia, anaesthetics, aquaculture techniques, *Tinca tinca*, fish physiology, fish culture, Czechoslovakia, haematology, menocain, propoxate, propanidide


Svobodova Z, Valentova V, Vykusova B, Pecena M (1986) **Ichtyotoxicological evaluation of the new Czechoslovak anaesthetic for fish.** *Bulletin of the Fisheries Research Institute, Vodnany.* 23(1):3-7
NAL Call No. SH1 B77
The Czechoslovak anaesthetic for fish introduced under the title of Monetan has been evaluated. The tests were carried out in carp (*Cyprinus carpio*). The methodology was based on the data recommended by the authors of the new Czechoslovak anaesthetic to achieve anaesthesia in carp, that is the dose of 0.1 g per 1 L of water at the temperature of 18-24°C in time period of 10 min. $LC_{50}$ value of Monetan for carp fry ($K_1$) in time period of 10 min and water temperature of 22°C was 0.81 g/L, minimum lethal concentration $LC_5$ in time period of 10 min and water temperature of 22°C was 0.49 g/L. $T_{50}$ value of Monetan (i. e. the time in the course of which 50% die using the recommended dose of 0.1 g/L and water temperature of 22°C) was 101 min, $t_5$ value (i. e. the time in the course of which 5% die using the recommended dose of 0.1 g/L and water temperature of 22°C) was 83 min.
*Descriptors:* anesthesia, hematology, lethal limits, *Cyprinus carpio*, anesthetics, toxicity tolerance, test organisms, Czechoslovakia, Monetan

Svobodova Z, Vykusova B, Kouril J (1992) **Menocain -- Czechoslovak anaesthetics for fish.** *Proceedings of the Scientific Conference on Fish Reproduction '92 (Vodnany, Czechoslovakia, 2-4 March, 1992)., Res. Inst. of Fish Culture and Hydrobiol., Vodnany (Czech Rep.).* pp. 152-153
Menocain is a specific fish anaesthetics which does not provoke anaesthesia in homoiothermic animals. There was confirmed on the base of toxicological, hematological, and histopathological investigations that this anaesthetics is safe for fish. Its suitability for fish anaesthesia was proved by several years of its successful application in fishery practice.
*Descriptors:* fish culture, aquaculture techniques, anaesthetics, haematology, histopathology, toxicology, Menocain


Sylvester JR, Holland LE (1982) **Influence of temperature, water hardness and stocking density on MS-222 response in three species of fish.** *Progressive Fish Culturist.* 44 (3):138-141
NAL Call No. 157.5 P94
Three responses of rainbow trout (*Salmo gairdneri*), common carp (*Cyprinus carpio*), and fathead minnows (*Pimephales promelas*) to the anesthetic MS-222 (tricaine methanesulfonate) were identified: induction times to total loss of equilibrium decreased with increasing temperatures; resistance to MS-222 increased with increasing water hardness; and resistance to the drug increased when the densitv of test fish was increased from 0.3 to 0.9 g/L in rainbow trout, 0.4 to 1.2 g/L in carp, and 0.3 to 0.8 g/L in fathead minnows. These results, and others from the literature, suggest that temperature, water hardness, and density of test fish, as well as pH and dissolved oxygen, may have significant interacting effects on the anesthetic properties of MS-222.
*Descriptors:* temperature effects, water hardness, stocking density, anesthetics, *Salmo gairdneri*, *Cyprinus carpio*, *Pimephales promela*s, response analysis, environmental effects


Takashima Y, Wan Z, Kasai H, Asakawa O (1983) **Sustained anesthesia with 2-phenoxyethanol in yearling rainbow trout.** *Journal. Tokyo University of Fisheries.. Tokyo Suisandai Kempo.* 69(2):93-96
ISSN: 0040-9014
The possibility of using 2-phenoxyethanol for long-term anesthesia in yearling rainbow trout, *Salmo gairdneri*, was examined. The 24 hour TLm was 320 ppm for trout yearling (100-200 g in body weight, at 12°C) and none of the fish immersed below 200 ppm died until 24 hours. All of the fish anesthetized below 200 ppm showed normal appearance and behavior after transferring to clean running water. Therefore, it was thought to be possible to anesthetize with 2-phenoxyethanol for at least 24 hours. On the other hand, serum cortisol levels analyzed by radioimmunoassay increased rapidly after immersion into 150

ppm of 2-phenoxyethanol for 1 hour. Moreover, prominent elevation of serum cortisol level was also recognized following mechanical agitation of rearing water in spite of anesthetic condition. It may be concluded that anesthesia with 2-phenoxyethanol does not reduce the stress during transport.
*Descriptors:* fish physiology, anesthesia, stress, fish handling, biological stress, *Salmo gairdneri*, phenoxyethanol


Tamaru CS, Carlstrom-Trick C, FitzGerald WJ Jr (1996) **Clove oil, minyak cengkeh, a natural fish anesthetic.** *Proceedings of the Pacon Conference on Sustainable Aquaculture '95*.pp. 365-371
NAL Call No. TC1505 P33 1995
Indonesian clove oil, minyak cengkeh, was found to be an effective anesthesia for use in hatchery practices with the rabbit fish *Siganus argenteus*. At a concentration of 25 ppm fish could be physically handled for length and weight determinations and for the performance of gonadal biopsy. Time to loss of equilibrium was less than three minutes at the lowest concentration tested and time to recovery was less than five minutes at all concentrations tested. No adverse effects or mortalities were observed during the two month study period. Clove oil was also found to be more effective than 2-phenoxyethanol under the same conditions and at the same dosages. The use of minyak cengkeh is a perfect example of how we in the developed countries tend to overlook the available resources in recipient countries of our technology transfer activities. Technology transfer, or technical assistance, most often involves the transfer of technology developed in a developed country to an undeveloped or a developing country by so-called experts in the developed country that developed the technology. Because the technology transferred is too often unfamiliar to the recipient, the materials needed to sustain the technology too often unavailable, and chronically the resources in the developing country are scrapped for the modern and more sophisticated ways of the “Western World”, we may have taught someone how to cook a gourmet dinner but he still won't be able to feed the family.
*Descriptors:* fish culture, hatcheries, aquaculture techniques, anaesthetics, *Siganus argenteus*


Taylor PB (1988) **Effects of anaesthetic MS 222 on the orientation of juvenile salmon, *Oncorhynchus tshawytscha* Walbaum.** *Journal of Fish Biology*. 32(2):161-168
NAL Call No. QL614 J68
Juvenile salmon, *Oncorhynchus tshawytscha*, were trained to orientate in a direction (270 degree) and then anaesthetized with ethyl m-aminobenzoate methane sulphonate (MS 222) in a test to determine whether anaesthesia affected the learnt orientation. Before anaesthesia the control group of twelve fish showed a mean unimodal orientation of 264°and a bimodal

axis of orientation of 258 °/78° with a confidence limit (second order analysis) of between 218 degree and 285°. After administration of MS 222 nine out of ten fish showed marked changes in orientation and random behaviour, persisting in two fish for more than 14 days. Eight weeks after completion of the anaesthesia trial the fish were retested. Each fish, except one, showed a mean bimodal axis of orientation that fell within the confidence limit of the control. The results support the view that the reference orientation in this study (270°) was a learnt, not an innate directional preference. The effects anaesthesia may have on salmon behaviour during migration are discussed.
*Descriptors:* anaesthetics, orientation behaviour, learning behaviour, *Oncorhynchus tshawytscha*, migrations


Tsuda Heizo (1987) **Experiments on the method of anesthetization of juvenile bluefin tuna.** *Bulletin of the Fisheries Research Institute, Mie, Japan.* 2:9-18
The juvenile bluefin tuna are weak in the skin, which is an obstacle to the research procedure such as weighing, measuring, transferring and so on. To safeguard the tuna against abrasion, the useful anesthesia has been studied over the period of 1983 to 1985. The tuna cultured in the tank, 210 g to 1970 g by weight, were used. Ulethane, MS-222 (m-aminobenzoic acid ethylester metanesulfonate), and eugenol (4-allyl-2-methoxyphenol) were examined as to the anesthetic effects to the tuna. In addition to this, when using cooled sea water and cooled sea water added ulethane, the effect was examined. The tuna were caught one by one with rod from the tank and transferred to the anesthetic solution prepared. After anesthetized, the tuna were weighed and moved back to the sea water, and then recovered from anesthesia. <<Abstract is partly entered herein due to the whole abstract is too long.>>
*Descriptors:* tuna fisheries, fish larvae, fish culture, anaesthesia, anaesthetics, *Thunnus thynnus*, bluefin tuna, urethane, MS-222, Eugenol


Tytler P, Hawkins AD (1981) **Vivisection, anaesthetics and minor surgery.** *Aquarium Systems*, pp. 247-278.
NAL Call No. SF457 A67
The following topics are considered: vivisection, immobilization and anaesthesia, humane killing of fish, surgery and surgical equipment, marking fish, electrocardiography, blood sampling and physiological saline solution.
*Descriptors:* fish handling, experimental research, anesthesia


Umbreit N (1980) **Chemical Restraint of Reptiles, Amphibians, Fish, Birds, Small Mammals and Selected Marine Mammals in North America: An Annotated**

**Bibliography (Technical note)**. *Bureau of Land Management, Denver, CO. Report Number: TN-340*,181 p. Note: Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703)605-6000 (other countries); fax at (703)321-8547; and email at orders@ntis.fedworld.gov
This annotated bibliography provides a list of available literature sources on anesthetizing or immobilizing small animals. Although the original intent of this bibliography was to deal strictly with small wild animals, it was expanded to include listing on many laboratory animals such as rabbits, rats, and mice. Extensive testing and research on these animals has led to better methods in handling, anesthetizing and immobilizing. For these reasons, it is hoped that the procedures and methods obtained in the laboratory may apply to the welfare, well-being and management of wild animal populations. Information has also been included on repellants, as they too are a form of chemical restraint.
*Descriptors:* mammals, wildlife, laboratory animals, constraining, bibliographies, amphibia, fish, birds, reptiles, tranquilizer drugs, anesthetics, repellants, dosage

Veenstra RS, Balon EK, Flegler-Balon C (1987) **Propanidid, a useful anaesthetic for studying blood circulation in early development of fish.** *Canadian Journal of Zoology.* 65(5):1286-1289
NAL Call No. 470 C16D
The effectiveness of propanidid was tested by comparing it with cocaine hydrochloride, urethane, and traicaine methanesulfonate, anaesthetics already established for studies of early ontogeny in fishes. Free embryos of the brook charr, *Salvelinus fontinalis*, and 7-day-old amargosa pupfish, *Cyprinodon nevadensis amargosae*, were anaesthetized with dilute solutions of these drugs. The times taken until the blood elements ceased moving through the capillary loops of the developing caudal fin were compared. Propanidid was found to be superior to the other drugs tested in maintaining the longest duration of unaltered blood flow.
*Descriptors:* anaesthetics, methodology, comparative studies, *Salvelinus fontinalis*, *Cyprinodon nevadensis amargosae*, blood circulation, propanidid


Wagner E, Arndt R, Hilton B (2002) **Physiological stress responses, egg survival and sperm motility for rainbow trout broodstock anesthetized with clove oil, tricaine methanesulfonate or carbon dioxide.** *Aquaculture.* 211(1-4):353-366
NAL Call No. SH1A6
Egg survival, sperm motility and physiological stress responses (plasma cortisol, glucose and chloride) of rainbow trout (*Oncorhynchus mykiss*) broodstock were compared among three anesthetics: tricaine methanesulfonate (MS-222), clove oil in the form of AQUI-S (a proprietary mix of 50% isoeugenol and other ingredients) and carbon dioxide gas. Concentrations of 60 mg/l tricaine, 20 mg/l isoeugenol (40 mg/l AQUI-S) and 220-275 mg/l carbon dioxide were based on preliminary tests and chosen to standardize induction time among anesthetics. Plasma glucose, chloride and cortisol concentrations indicated that none

of the anesthetics used after crowding and netting completely eliminated the stress response. The return to prestress cortisol levels differed among the three anesthetics. Fish anesthetized with AQUI-S had significantly lower cortisol concentrations at 1 or 7 h postimmersion than the other anesthetics and controls, but were elevated at 24 h. Plasma cortisol in tricaine- and $CO_2$-treated fish returned to prestress levels within 7 and 24 h, respectively, whereas cortisol levels in control fish remained elevated at 24 h. Sperm motility and duration of motility were assessed for a practical range of concentrations: tricaine, 15-100 mg/l; AQUI-S, 10-100 mg/l; $CO_2$, 50-173 mg/l. The percentage of motile sperm was unaffected by anesthetic treatment, averages ranging from 68% to 87%. However, duration of motility decreased as anesthetic concentration increased, averages ranging from 55 to 36 s for tricaine and from 56 to 37 s for AQUI-S. Duration of sperm motility was low (31-43 s) for all levels of $CO_2$ tested. Fish recovery time was significantly longer for fish anesthetized by AQUI-S (370 s) than the either $CO_2$ or tricaine (192 and 199 s, respectively). Gender had no effect on recovery time. Egg survival to the eyed stage and to hatch was not significantly different among anesthetic treatments and controls. No delayed mortality was observed for any of the fish handled and bled for the test. Results indicated that tricaine, AQUI-S and CO2 were all suitable for broodfish anesthesia, but the longer recovery time and lower cost for AQUI-S may make it more useful than the alternatives. None of the anesthetics wholly suppressed the stress responses during a typical spawning process, but did help reduce the duration of the stress responses and eased handling without compromising egg viability.
*Descriptors:* brood stocks, fish eggs, sperm, aquaculture techniques, induced breeding, anaesthesia, handling, carbon dioxide, biological stress, locomotion, survival, biological fertilization, *Oncorhynchus mykiss*, cortisol, clove oil, rainbow trout, tricaine methanesulfonate


Walsh CT, Pease BC (2002) **The use of clove oil as an anaesthetic for the longfinned eel, *Anguilla reinhardtii* (Steindachner).** *Aquaculture Research.* 33(8):627-635
NAL Call No. SH1 F8
To handle large river eels during procedures such as measuring and tagging for field and aquaculture studies, they must be anaesthetized. During our initial biological studies of *Anguilla reinhardtii* (Steindachner) it was found that the anaesthetic benzocaine was relatively expensive and elicited a variable response, even when used at relatively high concentrations. Human health risks are also a concern when using benzocaine, as some of the eels may later be sold for human consumption. Therefore, experiments were done to evaluate the use of clove oil (a safe, naturally occurring product) for anaesthesia of this species at a range of temperatures (17 and 25°C) and salinities (0-32 g/L. It was found that clove oil provided a suitable anaesthetic response through this wide range of temperatures and salinities. Response times were found to be relatively variable for both benzocaine and clove oil. This variability may be

related to stress, environmental factors, or the condition of the fish. Clove oil is recommended for anaesthesia of anguillid eels because it is effective, relatively inexpensive, and poses little risk to human health.
*Descriptors:* costs, aquaculture techniques, anaesthetics, Anguillidae, *Anguilla reinhardtii, Syzygium aromaticum*, clove oil, freshwater eels


Waterstrat PR (1999) **Induction and Recovery from Anesthesia in Channel Catfish *Ictalurus punctatus* Fingerlings Exposed to Clove Oil.** *Journal of the World Aquaculture Society.* 30(2):250-255
NAL Call No. SH138 W62
The use of clove oil as an anesthetic for channel catfish *Ictalurus punctatus* fingerlings was examined. At 100 mg/L, clove oil induced anesthesia within 1 min following exposure. Fish recovered from a 10-min period of anesthesia in 100 mg/L clove oil within 4 min following removal from the anesthetic solution. At clove oil concentrations of 150 mg/L or greater, recovery times were prolonged, requiring longer than 10 min for recovery. At 300 mg/L, mortality was observed with half of the catfish fingerlings failing to recover from the 10-min exposure. Fish could be safely maintained in 100 mg/L clove oil for periods of up to 15 min; exposure for longer than 15 min produced both prolonged recovery times and mortality. At a concentration of 100 mg/L clove oil produced responses similar to those of the commonly used fish anesthetic MS-222. The low cost of clove oil relative to MS-222 and the extensive testing and use of clove oil in dentistry and as a food ingredient make clove oil an attractive candidate as a fish anesthetic.
*Descriptors:* fish culture, anaesthesia, aquaculture techniques, fingerlings, mortality, *Ictalurus punctatus*, channel catfish


Weyl O, Kaiser H, Hecht T (1996) **'Breath holding' in tilapia *Oreochromis mossambicus*.** *South African Journal of Science.* 92(3):152-154
NAL Call No. 515 SO84
During experiments on the use of anaesthetics in fishes, it was observed that *Oreochromis mossambicus* was able to cease opercular movement for up to 15 minutes. It could be shown that this was not an immediate anaesthetic effect. The cessation of ventilation corresponded to a reduction of oxygen consumption. The pathway of detection of foreign substances appears to be olfactory. We discuss possible reasons for this specific, previously unobserved behaviour, as well as its consequences for culturing this and other fish species.
*Descriptors:* anesthetics, fish culture, oxygen consumption, olfaction, gills, respiration, *Oreochromis mossambicus*


Weyl O, Kaiser H, Hecht T (1996) **On the efficacy and mode of action of 2-**

**phenoxyethanol as an anaesthetic for goldfish, *Carassius auratus* (L.), at different temperatures and concentrations.** *Aquaculture Research.* 27(10):757-764
NAL Call No. SH1 F8
The objective of this study was to assess the efficacy and mode of action of 2-phenoxyethanol as an anaesthetic for two size classes of goldfish, *Carassius auratus* (L.), at three different temperatures. Goldfish (2.15 " 0.05 g, and 9.19 " 0.17 g) were exposed to 0.3, 0.4 and 0.5 ml 2-phenoxyethanol/L at 20, 25, and 30°C. Time needed to induce anaesthesia was dependent on concentration and water temperature. At temperatures at and below 25°C, 0.4 ml/L was needed to induce total loss of equilibrium within less than 15 min. Above 25°C, 0.5 ml/L was required to induce anaesthesia. Recovery rate was independent of the length of anaesthesia, which indicates that the anaesthetic is taken up and lost via a concentration gradient at the gill membrane and skin/solution interface. Fish recovered within less than 10 min after they had been taken out of the anaesthetic solution. In a second experiment, goldfish responded to a repeated exposure to 2-phenoxyethanol daily over a period of 14 days with increased tolerance, which indicates a habituation response to the anaesthetic. The use of 2-phenoxyethanol as an anaesthetic both for short-term anaesthesia and for anaesthesia under transport conditions is discussed.
*Descriptors:* anaesthetics, bioassays, fish culture, *Carassius auratus*, 2-phenoxyethanol


Yamamitsu S, Itazawa Y (1988) **Effects of an anesthetic 2-phenoxyethanol on the heart rate, ECG and respiration in carp.** *Nippon Suisan Gakkaishi/Bulletin of the Japanese Society of Scientific Fisheries.* 54(10):1737-1746
NAL Call No. 414.9 J274
Heart rate, ECG and respiratory parameters were measured with carp (*Cyprinus carpio*) of about 600 g during various stages of anesthesia induced with 400-800 ppm solution of 2-Phenoxyethanol. In 400 ppm solution, deep sedation, tachycardia, shortening of QT sub(1), increase in ventilation frequency and slight decrease in oxygen consumption were observed. In 600 ppm solution, disappearance of tachycardia, extension of time elements of ECG, and decrease in all respiratory parameters were observed. In anesthesia induced with 400-600 ppm solution, fish recovered from anesthesia by irrigation with fresh water containing no anesthetic. In 800 ppm solution, progressive bradycardia, remarkable extension of time elements of ECG and decrease in voltage elements of ECG, and drops to almost zero in respiratory parameters owing to cessation of ventilation movement were observed and fish did not recover from anesthesia by irrigation with fresh water.
*Descriptors:* fish physiology, bioassays, *Cyprinus carpio*, anaesthetics, 2-phenoxyethanol


Yokoyama Y, Yoshikawa H, Ueno S, Mitsuda H (1989) **Application of $CO_2$-anesthesia combined with low temperature for long-term anesthesia in carp.** *Nippon Suisan Gakkaishi/Bulletin of the Japanese Society of Scientific Fisheries.* 55(7):1203-1209

NAL Call No. 414.9 J274
The efficacy of $CO_2$ anesthesia combined with low temperature in long-term anesthesia supposing the transportation of live fish was evaluated using adult carp *Cyprinus carpio* acclimated at 23°C. All the carp became anesthetized in about 10 min with a 30-min cold treatment at 4°C and were safely maintained in an anesthetic state for the following 9.5 h with the cold-$CO_2$ treatment. The optimum anesthetic condition for adult carp was $pCO_2$ at 80 mmHg at 14°C.
*Descriptors:* carbon dioxide, water temperature, transportation, live storage, *Cyprinus carpio*, anaesthesia


Yoshikawa H, Ueno S, Mitsuda H (1989) **Short- and long-term cold-anesthesia in carp.** *Nippon Suisan Gakkaishi/ Bulletin of the Japanese Society of Scientific Fisheries.* 55 (3):491-498
NAL Call No. 414.9 J274
The efficacy of cold anesthesia in the transportation of live fish was evaluated using carp (*Cyprinus carpio*) acclimated at 23°C. The carp could be safely maintained in an anesthetic state for 5 h in water kept at 4°C and in the anesthetized or sedated state for 24 h at 8-14°C. Some anesthetized carp showed signs of convulsion when they received external stimuli, and bled mainly from gills. Hemorrhage became distinct with the decrease in temperature and the duration of the cold treatment. The sedated carp showed no such excitement and bleeding. The sedated state is considered to be adequate for transportation, regardless of the anesthetic time; 14°C seems to be the optimal temperature when the carp are acclimated to 23°C.
*Descriptors:* temperature effects, *Cyprinus carpio*, transportation, anaesthesia, cold-anesthesia


Zinkovsky OG, Potrokhov AS, Evtushenko NYu (1995) **The use of tranquillizers and antidepressants in experimental studies of fish.** *Gidrobiologicheskij Zhurnal (Kiev) Hydrobiology Journal.* 31(3):85-94
NAL Call No. QH90 A1G5
A series of drugs (phenazepamum, hydazepamum, phenobarbital, aminazinum) were tested on common carp (*Cyprinus carpio*) and silver carp (*Hypophthalmichthys molitrix*) for the applicability in fish-breeding as anaesthetic agents and antidepressants. Tentative pharmacological assessment is given. Methods and techniques allowing employment of the drugs in fish-breeding and related activities are discussed.
*Descriptors:* biological stress, fish physiology, anaesthetics, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, Ukraine

# *Web Resources:*

**2000 Report of the AVMA Panel on Euthanasia**
http://www.avma.org/resources/euthanasia.pdf

**Anadromous Salmonid Passage Facility Guidelines and Criteria** http://www.nwr.noaa.gov/1hydrop/hydroweb/docs/release_draft.pdf

A draft document which prohibits the use of carbon dioxide anesthesia.

**Canadian Council on Animal Care (CCAC)**
http://www.ccac.ca

The Canadian Council on Animal Care (CCAC) has posted its second draft of CCAC guidelines on: the care and use of fish in research, testing, and teaching. The draft guidelines, and future final guidelines are available at the CCAC webpage (http://www.ccac.ca and http://www.ccac.ca/english/new/newframe.htm).

**CVM Guide 1240.4200**
**Low Regulatory Priority Aquaculture Drugs**
http://www.fda.gov/cvm/index/aquaculture/LRPDrugs.pdf

**CVM Guide 1240.4260**
**Classification of Aquaculture Species as Food or Nonfood**
http://www.fda.gov/cvm/index/policy_proced/4260.pdf

**Drugs Approved for Use in Aquaculture**
http://www.fda.gov/cvm/index/aquaculture/appendixa6.htm

**Endangered Species Act Section 7 Consultation Supplemental Biological Opinion**
http://www.nwr.noaa.gov/1hydrop/hydroweb/docs/Final/chap11.pdf

Biological opinion which mentions anesthetics in fish and the excessive thrashing caused by $CO_2$

**FDA-CVM Guidance Document 150**
**Guidance for Industry, Status of Clove Oil and Eugenol for Anesthesia of Fish**

http://www.fda.gov/cvm/index/updates/gl150.htm

**FishDoc – The Home of Fish Health**
http://www.fishdoc.co.uk/index.htm

**Fish Anaesthetics:**

**Why use anaesthetics for treating fish disease?**
http://www.fishdoc.co.uk/treatments/anaesthetics01.htm

**Types of anaesthetics**
http://www.fishdoc.co.uk/treatments/anaesthetics02.htm

**How to use anaesthetics**
http://www.fishdoc.co.uk/treatments/anaesthetics03.htm

**For use in euthanasia**
www.fishdoc.co.uk/treatments/euthanasia.htm

**Food Animal Residue Avoidance Data Bank (FARAD)**
www.farad.org

**MS222 (Tricaine Methane Sulphonate)**
http://www.alpharmaanimalhealth.co.uk/VPDF/MS%20222.pdf

**...** transport anaesthesia vaccination, minor surgery deep anaesthesia major surgery, euthanasia For further **...** Anaesthesia and Restraint. In: Textbook of fish medicine **...**

**Recommendations for euthanasia of experimental animals: Part 1**
http://www.ifp.kvl.dk/education/animal/Tekster/Euthanasia%201.pdf

Ross, L.G. & Ross, B. 1999. **Anaesthetic and sedative techniques for aquatic animals. Second edition.** Fishing News Books. Blackwell Science. Oxford. pp176. ISBN 0-632 05252X
http://www.aquaculture.stir.ac.uk/GISAP/Pubs/A&S.htm

Ross, L.G. & Ross, B. 1984. **Anaesthetic and sedative techniques for fish. Institute of Aquaculture Handbook**. University of Stirling. pp45. ISBN 0-901636-52-5
http://www.aquaculture.stir.ac.uk/GISAP/Pubs/A&S.htm

**Species Specific Anaesthesia**

**Woods Hole Oceanographic Institute**
Bibliographic listing of resources
http://www.mblwhoilibrary.org/animal/seven.html

**White Paper Summary of Research Related to Transportation of Juvenile Anadromous Salmonids Around Snake and Columbia River Dams**
http://www.nwfsc.noaa.gov/publications/whitepapers/trans4-25-00.pdf

**A letter (with several pieces of follow-up correspondence) from FDA to USFWS regarding the use of non-approved drugs on threatened and endangered species** is freely available, but you must request these from **Dr. Dave Erdahl (406-587-9265 x125, dave_erdahl@fws.gov) of the USFWS** who has the current INAD for the use of isoeugenol.

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